THE BODY IN HEALTH

O'SHEA and KELLOGG

HEALTH SERIES of PHYSIOLOGY and HYGIENE


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HEALTH HABITS

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THE BODY IN HEALTH

MAKING THE MOST OF LIFE

THE HEALTH SERIES

OF

PHYSIOLOGY AND HYGIENE

THE BODY IN HEALTH

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INTRODUCTION

It is the aim in "The Health Series of Physiology and Hygiene" to present in an attractive form for pupils in the elementary school the latest and most accurate knowledge relating to physiology, and especially to the hygiene of daily life. The constant effort of the authors has been to make scientific knowledge so simple, so concrete, and so captivating that pupils can hardly fail to take an interest in the problems of preserving health for the purpose of making the most of life.

Throughout the series, the aim has been kept in view of awakening in the young a normal desire to live in such a manner as to develop strength and preserve health, because in this way the individual will have the greatest success in securing the things which he desires, and in avoiding the disabilities and pains which otherwise are likely to occupy a considerable part of his life. Comparatively little attention is given to anatomy, and only sufficient physiology is presented to constitute a basis for the facts of health which are discussed.

Very extensive use is made of photographs and diagrams illustrating every-day life in the city and in the country. There is at least one interesting and practical original exercise suggested for every principle of health presented

in any lesson, and it is the plan that each pupil should work out each exercise and report upon it during the recitation period. In order further to assist the teacher and the pupil, a list of questions, fully covering the text, has been given at the end of each chapter.

PREFACE

EVERY one would like to have a good, vigorous, well-poised body, free from aches and pains and fit for any kind of work or pleasure. How can one develop and maintain his body in this condition? The Third Book of the Health Series is designed to answer this question. First, it is shown how habits of living will affect stature, symmetry, strength, and poise of the body. Much attention is given to the problem of how to keep the vital organs in good working order so that they can destroy the enemies of the body and furnish energy for all the work one wants to do. When one does not feel fit for the work he has to do, what may be the cause? This question is discussed in detail also. In a concrete, practical manner, suggestions based upon a great deal of investigation as well as experience are made in respect to the sort of exercise which will be best for different people and different purposes, how one may increase his endurance, and what kind of habits will reduce one's capacity to do work without fatigue.

A person cannot keep in fit condition without giving heed to what and how he eats and drinks; and these matters are considered in detail. Many people deliberately handicap themselves in the race of life, though they may

not be aware of what they are doing. They take into the body things which lessen their courage, ambition, and working power, so that they lose out in competition with others who avoid these bodily enemies. This book goes into all these matters in a simple, concrete way. Topics concerning the elimination of poisons from the system, helping the body to repair itself when it becomes worn, and fortifying it so that it can defend itself against attacks from without as well as from within, are given a prominent place in the book. One cannot have the kind of body he desires, so that he can get the most out of life, unless the mind as governor of the body is properly trained and kept in a condition of health and poise, so this subject is treated herein.

The authors of the Health Series believe that one of the best ways to impress facts of health is to present them to the eye in photographs and drawings. So this book is fully illustrated with pictures made especially for this purpose. As an aid to teacher and pupils, each topic discussed is indicated in a marginal heading. The authors further believe that in order to get the most out of their study of hygiene, pupils should apply principles of health in their every-day life, and so the authors have given at the end of each chapter a number of problems relating to health. It is expected that each pupil will work these out and discuss them in class. Lastly, a detailed list of review questions is added to each chapter, and an index is given at the close of the book.

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THE BODY IN HEALTH

CHAPTER I

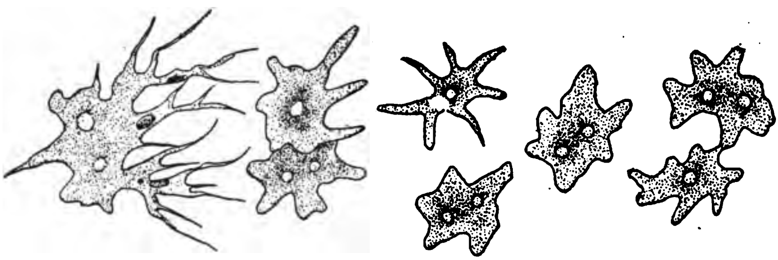
The Little Workers of the Body

If you look at a house from a distance, you can see only its general form and outline. As you come closer to it, you can see distinctly the bricks of which the house is made. You discover then that the house, instead of being just one object, is made up of a number of smaller ones.

Like the house, the human body is composed of many small parts. The tiny living bricks of which the body is built are called *cells*. These cells are so small that they cannot be seen at all by the "naked eye." When we examine a piece of flesh under a microscope, we see that it is made up of separate, distinct, perfectly formed, and exceedingly small parts. Though these parts differ greatly in shape, color, and use, they are all *cells*.

All living things, both vegetable and animal, are composed of cells. Things that have no life, such as stones, water, and air, are not made of cells. But everything that lives, animal as well as vegetable, is made up of wonderful tiny cells.

There are some minute animals which consist of just a single cell. The *amœba*, found in ditch water and stagnant pools, is a good sample of a single-celled animal. It will be easy for you in the summer time to get specimens of the amœba for study from a ditch or pond. Of course, you will have to use a good microscope. Why? In winter, a small pond may be arranged by putting some hay in a saucer with hydrant water and setting it away for two or three weeks in a



THE AMŒBA MANY TIMES ENLARGED. IN FORMING NEW AMŒBÆ THE MOTHER CELL SIMPLY DIVIDES INTO TWO NEW CELLS.

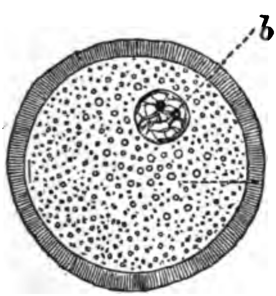
warm place. A little fresh water must be added daily to take the place of that which evaporates.

This minute, one-celled animal, seen under the microscope, looks much like a small drop of jelly. It has no mouth, yet it can eat. It spreads itself over or around a particle of food and absorbs it, just as water flowing down a pane of glass may pick up particles of dust. It has no limbs, yet it moves easily and rapidly from place to place. It stretches itself out in the direction it wishes to travel and draws

itself along like a worm from place to place, continually changing its form. It eats, breathes, works, and rests. This wonderfully simple and fragile little cell is just as clearly and distinctly an animal as is a horse, an elephant, or a man Yet it is so minute that it takes eight hundred and fifty amœbæ arranged side by side to make a row an inch long; and one hundred can swim about in a drop of liquid which would hang on the point of a pin.

A DIAGRAM OF A CELL MADE TO SHOW THE NUCLEUS ESPECIALLY.

Where do the cells of which all living things are formed come from? Every cell comes from another cell. How are they formed? They are formed by the dividing of each cell into two new cells, as you see in the picture, and the process goes on until millions of cells are formed.



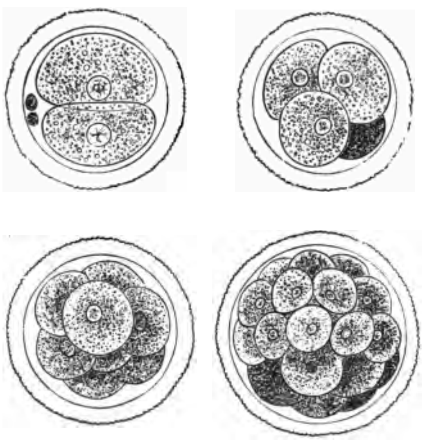
THIS SHOWS THE NUCLEUS (*b*) IN A REAL CELL.

How the cells are formed.

When you examine the jelly-like mass of the amœba under the microscope, you see in it a dense, grayish portion, which is the *nucleus* of the cell. When the cell is preparing for division, the nucleus divides and part of it goes to each end of the cell. A wall is then formed across the middle of the cell, and it separates

into two parts. Each part is a complete new cell, having its own nucleus. When a single-celled animal divides in this way, each of the new cells forms a complete new animal, which grows to the size of the parent.

The bodies of animals larger than the amœba, instead of being formed of a single cell, may be made up of millions of cells, each one of which is quite as much an independent living being as is the amœba. Each animal body begins with a single cell; but when this divides, the cells do not separate and live alone, as in the case of the single-celled animals. They remain together and keep on dividing and dividing until there may be many millions of them, a great colony, all living together and working for the good of each.



NOTICE HOW THE MOTHER CELL DIVIDES TO FORM NEW CELLS, AND THEN UNITES INTO COLONIES.

Cell colonies or communities.

The body might be compared to a swarm of bees, only that in the case of the bees each one may live for some time separate from the rest if he chooses to do so. This is true to a small extent of the cells of which animals and plants

are composed. When a portion is cut from a plant or animal, its cells do not always die at once. The legs of a frog will twitch and kick after they are severed from its body. The heart of a turtle will continue to beat for hours after its head has been cut off. When some kinds of worms are cut in two each part will live and grow into a complete worm. A flower stem cut from a plant will continue to live and bloom for days in water. A branch cut from the parent tree and stuck in the ground may even grow into a new tree. This is because each part, being made up of separate little living beings, has its own life.

For this reason it is possible to remove a portion of one animal and graft it upon another animal of the same kind. In the ordinary process of grafting fruit trees, a bud of one tree is planted in a little slit cut in the bark of another tree. When the work is well done, the bud soon becomes accustomed to its new home and grows and bears fruit and leaves like its parent.

In somewhat the same manner, surgeons sometimes take portions of skin from one or several persons to graft upon another person who has lost by burning or some other accident large portions of skin. Many cases have occurred in which a portion of a finger, when cut off, has been replaced and has grown secure. Surgeons often graft in portions of bone to repair diseased or injured limbs, and Dr. Curel of the Rockefeller Institute has successfully transplanted kidneys and other organs. Organs and tissues may be kept

alive for months after removal from the body, and certain tissues may be made to grow.

The human body a community.

The human body may well be compared to a community made up of multitudes of individuals. There are no idlers in this community; all the cells are active workers. In most communities there are different classes of workers, such as merchants, blacksmiths, chemists, bakers. In the body, likewise, there is a division of labor. Some cells build, others tear down. Some may be compared to artists; and others, to scavengers; that is, there are cells which work to keep the body clean and healthy. Some make different kinds of fluids to be used in the body. There are cells that stand as sentinels to give the body warning of danger, and others that are little soldiers who defend it against the enemies of life and health.

Cell structures or tissues.

In the building of a house different sets of workmen are employed for the different parts: bricklayers for laying the brick walls; carpenters for the doors and other woodwork; plumbers for the drainage pipes; and so on. In like manner, the little cell builders form themselves into groups for building up the different structures needed in the body. The different kinds of cell structures are called tissues. A large part of the work of the cells is to build and repair these living tissues of which the body is composed.

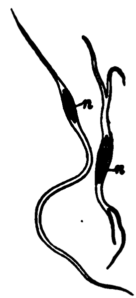
Some of the cells form long, white, thread-like fibers,

very tough and unyielding. This white fibrous tissue is needed to bind the different parts of the body together and to make cords and protective coverings. There is also a yellow elastic tissue, which may be stretched like India rubber.

The yellow elastic tissue and the fibrous tissue together form in all parts of the body a marvelously

WHITE FIBROUS TISSUE.

YELLOW FIBROUS TISSUE.



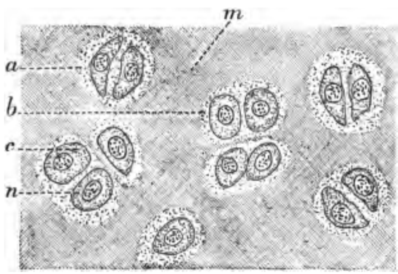
CELLS IN MUSCULAR TISSUE. *n*, nucleus.

strong though elastic structure, a finely woven meshwork called connective tissue. This binds the tissues together, forms sheaths, membranes, bands, pouches, and coverings, and serves everywhere for purposes of protection and support.

The meshes of the connective tissue network are in some parts of the body occupied by cells filled with fat. This soft adipose tissue, as it is called, rounds out the form, forms cushions for delicate organs like the eye, and serves other useful purposes.

Other groups of cells form what is called muscular tissue by which all sorts of movements are made. This is made up of minute fibers which shorten and lengthen much as an earthworm contracts and extends its body in motion.

The hardest of the tissues which the cells build up in the body is called bone or osseous tissue, which is stronger than the toughest oak. The bones serve as supports for the body and as levers by means of which it is moved about by the muscles.



THIN SECTION OF CARTILAGE, HIGHLY MAGNIFIED.

a, group of two cartilage cells; *b*, group of four cartilage cells; *c*, cell body of cartilage cell; *m*, intercellular substance (cartilage); *n*, cell nucleus of cartilage cell.

Something like the bone tissue, but softer, and capable of bending under pressure, is the cartilage tissue, which is usually connected with the bones.

The most remarkable groups of cells found in living beings are in the nervous tissue, of which the brain and nerves are composed. These do the thinking and feeling for the body community.

Layers of curious cells cover the whole surface of the body and line all its cavities. These are called epithelial cells, because the skin or covering that they help to form is called epithelium.

SECTION OF EPITHELIUM SHOWING CELLS.

Among the most wonderful of the many millions of cells in the body are the gland cells. The glands are groups of cells which form some peculiar substance for the carrying on of the work of the body. There are many different kinds of gland cells. Some sets of these cells form saliva; others make gastric juice; others are found in the liver making bile. Millions of little groups of cells found in the skin make sweat; others make fat, which oils the hair and the skin. Other gland cells separate from the blood poisonous substances which are formed in the body or which are taken in with the food or drink.

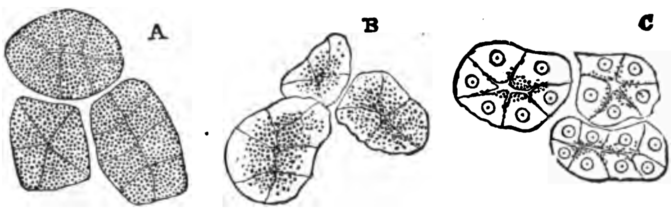
Gland cells.

EPITHELIAL CELLS.

In studying these cells and their work, one is constantly led to marvel at their intelligence, faithfulness, industry, and perseverance. In the action of a gland cell or tissue-building cell we see creative power manifested. The same creative power is required to enable

a cell to build the minutest thread of fibrous tissue as was required to make the first man.

The one-celled animal, living alone, must do everything for itself. All that is necessary for its life must be performed by that single cell. It moves itself about, gathers its own food, eats and digests it, and discharges its wastes. In the community of cells that form the living body, however, the work is divided up. The cells doing the same kind of special work for



GLAND CELLS.
a, after rest; *b*, after slight activity; *c*, after greater activity.

the body are grouped together, and these cell groups are called organs.

Cell groups called organs.

All many-celled animals and plants have the work divided up among the different organs, and so are said to be organized and are sometimes spoken of as organisms. They are said to belong to the organic world. A rock or a mountain, which has no organs, is said to belong to the inorganic world.

As the wood, brick, stone, and mortar are combined and arranged to form the parts of a house and its furniture, so the simple structures or tissues are combined

and arranged to form the different organs of the body. In the hand, for example, we have bone, muscular, connective, and skin tissue combined in such a way as to form an organ suitable for grasping. Some organs, like the heart, are made chiefly of one kind of tissue.

Each organ has its special work to do for the body, and the life and health of all the cells depend upon its work's being well done. The stomach is an organ for digesting the food, and if it should fail in this work, all the body cells would starve. The lungs take in the oxygen that the cells need, and the kidneys remove poisonous and waste matters. The heart pumps the blood which carries the food supply to every part of the body, so that all the cells are supplied with nourishment. The brain and spinal cord send out tiny living threads, called nerves, which run throughout the body, dividing and subdividing until they reach every portion, bringing under their influence each individual cell, with the exception of the floating cells in the blood.

Cells and organs in health.

When all the cells and organs of the body are acting properly, a person is said to be in a state of health. When anything interferes with the work of any of the organs so that it is done imperfectly or not at all, the person suffers discomfort and is said to be in a state of ill-health or disease. It is of the utmost importance that the vast army of little workers of which we are formed should be kept in health and vigor. Anything which injures them or hinders their activity is dangerous to our life

and health. There are some things which have a very injurious effect upon the bodily organs; among these are tobacco and alcohol.

By numerous experiments upon animals, and by examinations made after death of persons who had used alcoholic drinks, it has been found that every

HERE YOU SEE YOUNG MEN IN A STATE OF HEALTH.

tissue of the body, especially the liver and the brain, is injured by alcohol. Alcohol lessens the activity of the cells that build the body and, taken in strong doses, may even paralyze them completely. This is one reason why a person who takes alcoholic drinks does not recover from an accident so quickly as one who does not use alcohol. The cells are hindered

in their work of repairing the damage that has been done. Many eminent surgeons have noticed this fact.

Tobacco has the same effect as alcohol upon the tissue-building cells. This is the reason why the boy who begins to smoke at an early age is puny and stunted in his growth and not properly developed. All physicians will tell you that the use of tobacco by young persons is a most injurious habit.

Health Problems

1. Find out the meaning of *cell*. Do you think the term *cell* is a good one for the very small parts of the human body of which all organs are composed?
2. Suppose you were talking with a person who thought that stones were made up of cells. What should you say to him to make it clear to him that cells are found only in living things?
3. Mention several communities or colonies of cells in the human body. What are these communities or colonies called?
4. Do you know any animal besides the amœba that becomes two simply by division?
5. Have you ever seen a tree grafted? How was the work done? Did the graft live? If so, explain how this was possible.
6. What does it mean to say that the body is a community? Show in what way it resembles a community like the one in which you live, in number and in kinds of workers.
7. Look up the meaning of tissue. Is it proper to call some of the organs of the body tissues? Why?
8. Show in your body an instance of white fibrous tissue; connective tissue; adipose tissue; osseous tissue; cartilage tissue; muscular tissue; nervous tissue.
9. Suppose some one organ of the body did not do its duty.

What would happen in the body? Is it the same way in the community in which you live, if some person does not do his duty?

10. What does it mean to be in a state of health? What is the opposite of a state of health?

Review Questions

1. Why can we not see the cells of the human body with the eye alone?

2. Suppose you should examine a piece of flesh under a microscope. What should you see?

3. How can one get specimens of the amœba for study?

4. Describe the amœba seen under the microscope.

5. How are the cells of the body formed?

6. What is the nucleus of the cell? What happens to it when any cell is about to become two cells? Of what are the bodies of large animals made? With what does the body of every animal begin?

7. What does it mean to say there is "division of labor" in the human body?

8. How are the tissues of the body made up?

9. Mention the various kinds of tissues and their uses.

10. What are the epithelial cells? Where are they found?

11. What are the gland cells and what are their uses?

12. What is the meaning of organs? Mention a number of organs in the human body.

13. Mention the tissues which compose the hand.

14. What is necessary to keep the body in a state of health?

15. What has been found regarding the influence of alcohol upon the workers of the body? What organs are hurt the most by alcohol?

16. What is the effect of tobacco upon the workers of the body?

CHAPTER II

The Maintenance of the Body

No large community of people remains exactly the same for any length of time. Constant changes take place in it. Daily some of its members are dying or leaving, new ones are being born, and others are coming in from other places. When the number added is greater than the number lost, the community grows in size, of course. Do you know that this is true also of the communities or colonies of cells that compose the living body? Many millions of the cells die in the course of a single day. Eight million blood cells are dying every second of our lives. If no new ones were supplied to take their places, what would happen to the body? Besides the cells needed to take the place of those that have died, the child or the young animal needs an increase of cells to provide for its growth. Why?

How we grow.

All living things grow. This is one of the chief differences between the organic and the inorganic world. A lifeless object, such as a rock or mountain, does not grow, although it may increase in size by the simple addition of material. Living things, plants and animals, grow by taking

material into themselves and changing it into their own substance. The growth of a human being, from the very beginning until he reaches the full stature of a perfect man, takes place only through the making over of the food he eats.

All the cells of the body, which are living and active, need food to maintain their life and supply them with energy for their work. *Hunger* is the appeal of the cells for more food.

The living body is both like a house and like a machine. A machine wears out much more quickly than a building, for the reason that it works. The work performed in and by the body wears it out so that it is in constant need of repairs. The wearing out process is so great that the entire body is rebuilt many times during a long life. How is the material for the necessary repairs supplied?

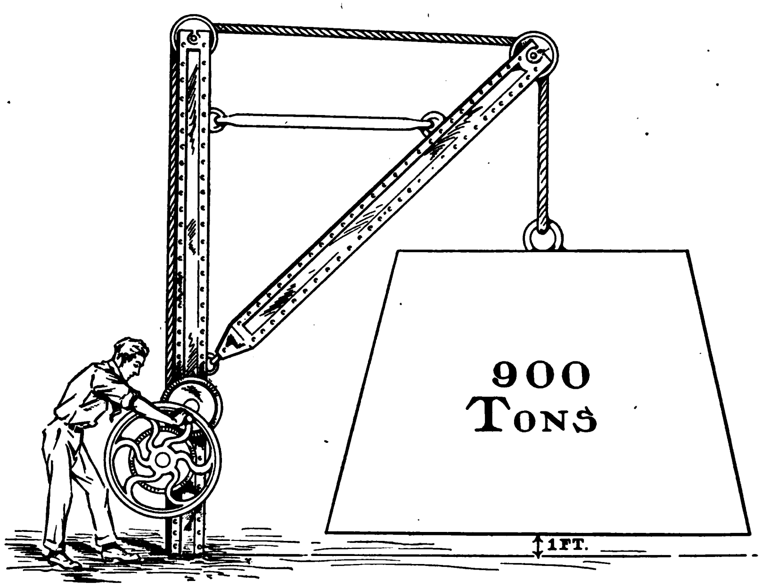
The living human body is always warm. In summer or winter, no matter what the temperature of the surrounding air may be, the body temperature is always maintained at nearly 100°. In *Health Habits* you have learned something about the *combustion*, or slow burning, by which the body heat is kept up. To produce heat, something must be consumed. The life fire that warms the body consumes it just as burning consumes a candle or as fuel is consumed in the stove. Of course, a constant supply of fuel is needed to keep this life fire steadily burning. How is this supply furnished?

What is ordinarily spoken of as fire is an active burning, accompanied by a flame. When combustion is less active, the heat is less intense, and there may be no visible flame. It is by this latter sort of combustion that a dead tree, lying upon the ground in the woods, is gradually consumed. In time it will disappear as completely as though it had been burned up in the stove. The amount of heat produced by the burning of a tree is just the same, whether it rots in the forest or is burned in a furnace; but in the furnace the heat is given off in a much shorter time. The amount of heat produced by the body every hour has been estimated to be sufficient to raise two and a half pints of water from freezing to the boiling point, or to boil seven gallons of ice water every twenty-four hours.

How the cells get their energy.

Another important source of bodily waste is work. Work, like heat, requires the consuming of something. The locomotive can not pull its train of cars without using coal. You know, I suppose, the amount of fuel consumed by a locomotive is in proportion to the amount of work it does. So the locomotive which pulls the largest train consumes the most coal. Just as the locomotive gets its power to work from the fuel that is burned under its boiler, so the cells in the body get their power to work from the food that is used in it. All the work done in and by the body consumes materials that must be made good by the food supply. The body, therefore, has *only one source of energy. That is food.* The

greater the amount of work done, the greater the amount of food needed. Think for a moment of the tremendous amount of work done daily by the cells of the body. It has been carefully estimated that the work which the body is capable of doing daily is equal to the lifting of 900 tons one foot high. More



THE BODY IS CAPABLE OF DOING AN AMOUNT OF WORK EACH DAY EQUAL TO LIFTING 900 TONS ONE FOOT HIGH.

than one seventh of this work is done by the heart, which is constantly at work, without a moment's rest day or night, pumping the blood to every part of the body. The work of the lungs and of the muscles

that move the breathing apparatus also goes on every moment during life. The balance of the work is done by the muscles of the limbs and the trunk. To perform in ten hours with the muscles all the work done daily by the body, a man would have to lift his own weight a foot high every three seconds.

We see then that there are two things that the food supplies to the body: material for the building of body tissue, — bone, muscle, blood, brain, and all the organs of the body; and energy, which is used in the body in many different ways, — producing heat, doing muscular and mental work, keeping the heart beating, and enabling all the different organs and glands of the body to perform their work.

An examination of human dust shows us the materials of which the body is composed. The following table shows the different substances, and the amounts of each, in the body of a person weighing 150 pounds. You need not try to remember these different things now; only look them over to get an impression of what the body is made.

ELEMENTS		
Oxygen	97.5	Pounds
Carbon	27.0	"
Hydrogen	15.0	"
Nitrogen	4.5	"
Calcium	3.0	"
Phosphorus	1.5	"
Potassium	.5	"

ELEMENTS		
Sulphur	.4	Pound
Chlorine	.2	"
Sodium	.2	"
Magnesium	1.2	Ounces
Iron	.1	"
Fluorine		Traces.
Silicon		"

Let us now see where we get the material that forms our bodies. Where does it come from? Every particle of it comes from the earth, the air, and the water. The human body, however, does not have the power to make living substance out of earth and air. Animals can use as food only substances that have been prepared for them by plants. Here, for instance, are a piece of bread and a piece of coal. Both contain material and energy, and some of the same elements. Yet one is a food, and the other is not a food. The coal may be burned in a locomotive to furnish both heat and energy, but it can not be so used in the human body.

Where the material in the body comes from.

WHY CAN NOT THE COAL BE BURNED IN THE BODY?

You must see that the material coming from the earth, the air, and the water must first pass through

the plant, before it can be used by animals as food. The plant is the workshop or factory where the food for animals is produced. A plant, to illustrate, takes from the air carbonic acid gas, about which you have already learned. This is not a food. From the soil the plant takes up water, which is not a food. Out of these two combined it makes starch, which is a food. Sunlight, the great source of energy, can not be absorbed directly and used by the body. The energy you use to-day in doing your daily work was at one time in the form of sunbeams, which were picked up by a plant, changed into chemical compounds, and stored up. Every vegetable product, as wheat, corn, potato, is such a storehouse. Every fruit, every seed, every nut, is a little bundle of concentrated light, stored until it is needed for the growth and development of a new plant or to furnish heat and energy to some member of the animal kingdom.

Plants the only food producers.

This calls our attention to an important difference between plants and animals. A plant is a food *producer*, a *storehouse* of energy. An animal is a *food consumer*, an *expender* of energy. Animals, although they are sometimes used for food, do not *make* foods. A plant is the only real food factory; the only place in the world where a food is actually *produced*. A lion, in dining upon an antelope, is only eating at second-hand the grass and herbs which the antelope has eaten. A man, in eating roast beef, is taking at second-hand the corn upon which

the ox was fed. If animals were to feed upon each other only, the animal kingdom would soon disappear from the face of the earth. Animals eat the foods produced by plants. Without plants animals could not live.

We must now study the substances that are adapted to serve as food for man. A substance which can be used by the body to furnish it with material for building or repairs or with energy for heat and work is called a nutrient. We have seen that one purpose of food is to supply the body with warmth and power to work. These special needs are met by two classes of nutrients, carbohydrates (starch, dextrine, and sugar) and fats. The building material for the body is furnished by another class of nutrients called proteins. These — carbohydrates, fats, and proteins — are the three great classes of nutrients.

Composition of foods.

In addition there are: —

Salts, which are essential not only for the bones, but for all living tissues of the body. (By salts we do not mean "table salt," but organic combinations of lime, magnesia, phosphorus, potash, and other elements);

Flavoring Substances, which render the food agreeable to the taste;

Cellulose, an indigestible substance found in all vegetable foods, which is highly essential to give bulk to the food mass and stimulate the activity of the stomach and intestines.

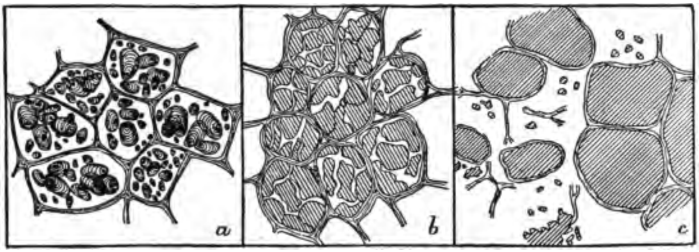
Vitamines, subtle substances which are found in fresh, uncooked foods and which are absolutely necessary for the complete nourishment of the body. These substances are so refined and so active that little more is known about them except the fact that they exist and that they are likely to be destroyed by cooking. Sailors get scurvy by the exclusive use of cooked food. Canned food is especially objectionable.

We have already learned that starch is made by the plant out of carbonic acid gas, which it gets from the air, and water, which it gets from the earth. Starch is the most abundant of the nutrients. It is found in all grains and vegetables, and in green fruits, though not in ripe fruits.

Starch consists of little granules, each one of which is inclosed in a tiny envelope made of a woody substance, called cellulose. For this reason, raw starch can not be digested well by a human being. The process of cooking breaks up the envelope and releases the starch, which can then be reached and acted upon by the digestive fluids in the body. The picture shows different forms of starch granules found in the common grains and vegetables.

Sugar, although very unlike starch in looks and taste, is almost like it in composition. When starch is digested, it is made into sugar. Sugar is found in all fruits and in some vegetables, such as corn, beets, and sweet potatoes. There are different kinds of sugars. The sugar of fruits is called fruit

sugar. A sweet substance found in milk is known as milk sugar. A peculiar sugar produced in the sprout-



STARCH CELLS OF POTATO.
a, cells of raw potato; *b*, cells of partially cooked potato; *c*, cells of thoroughly boiled potato.

ing or malting or grain is called malt sugar or maltose. Sugar furnished by the sugar cane, the beet root, or the sap of the maple tree is known as cane sugar.

Fats are found in both animal and vegetable foods. Butter, lard, and suet are the principal forms of animal fats used as foods. Vegetable oils come chiefly from nuts, from various seeds such as the cotton seed, and from oily fruits such as the olive.

Proteins contain the carbon, hydrogen, and oxygen found in fats, starch, and sugar, and in addition to these they also contain nitrogen, and for this reason they are sometimes called nitrogenous foods. Proteins are abundant in animal foods, — lean meat, milk, cheese, and eggs. Of the foods obtained from plants, proteins are found chiefly in nuts, peas, beans, and lentils, though they are contained also in all grains and in very small quantities in most vegetables.

List of Common Foods Rich in Proteins, Fats, and Carbohydrates

PROTEINS	FATS	CARBOHYDRATES
(*Animal*)	(*Animal*)	
Milk Cheese Eggs Meat	Milk Cream Butter Egg yolk Suet Lard Fat meat	
(*Vegetable*)	(*Vegetable*)	(*Vegetable*)
Legumes (dried peas, beans, lentils) Nuts Oatmeal Wheat	Nuts Cocoanut oil Olive oil Other vegetable oils	All cereals, All foods made from cereals, Starchy vegetables, particularly the Irish potato, Sweet potato, Dasheen, Green corn, Green peas, Sweet fruits, Figs, Banana, Apple, Prune, Pear, Raisin, Sugars, Legumes, Chestnuts, and some other nuts

The carbohydrates and fats, which are composed of the same elements (carbon, hydrogen, oxygen), serve the same purpose in the body. They are the fuel

or energy-giving foods, which are burned up in the body to furnish it with warmth and power to work. When not needed for immediate use, they may be stored up in the tissues of the body, just as coal is stored up in the tender of a locomotive, to be used as needed.

Uses of the different foods.

The proteins are a most important class of nutrients because they furnish the building material for the body. Just as the carbohydrates and fats correspond to the coal burned in the locomotive, the proteins correspond to the iron, brass, and other materials out of which the locomotive is made. Nitrogen, which is contained only in protein, is the element needed for cell building, and it is this that gives the protein foods their great importance. A growing child, whose body is in process of building, needs these nitrogenous foods in larger quantities than a person who is full-grown and needs only the material necessary for repairs. The foods which nature has provided for the use of the young animal are rich in proteins. The white or albumen of the egg, out of which the young chick is to be constructed, is composed wholly of this element. Milk, also, which is the natural food for young animals, contains an abundance of protein.

OATS, CORN, WHEAT, AND RICE MAKE EXCELLENT FOODS WHEN PROPERLY PREPARED. WHY?

Proteins may be burned in the body to furnish energy, but their chief use is for building material. There is no provision in the body for the storing up of the proteins, or building foods, as there is for the storage of the fuel foods, hence it is important to take just the proper amount each day.

Certain *minerals* are needed in small amounts. Of these common *salt* is the one most familiar to us. This is found in sufficient quantities in most of our foods, but we often add more in cooking and eating, — often too much. Lime, which is used in making bones and is especially needed by a growing child for the building up of his body, is found in milk and grains and eggs. A small amount of iron is needed for the formation of the red blood cells. This is found in some fruits, especially in the strawberry and the apple, in the yolk of egg, and in the green parts of vegetables. Raw foods, such as celery and lettuce, are valuable for the minerals which they furnish.

FRUITS CONTAIN MINERALS AND MUCH WATER.

Another substance very necessary to the body is

water, which as you know comprises a large part of the body. Water is lost from the body chiefly in the removal of wastes. But besides that which is carried off through the bowels and kidneys, water is also constantly passing off through the lungs and skin, in the form of an invisible vapor. The moisture of the breath can be seen when one is in the open air on a frosty morning. When one exercises violently, or is exposed to great heat, the water thrown off by the skin becomes visible in the form of perspiration. The amount of water lost daily is three or four pints, and this loss must be made good by drinking or getting water in our food. Besides the water that we drink, we get a considerable amount in our foods. Even what are called dry foods, such as rice and beans, contain some water, and other foods are largely composed of it. Potatoes, for instance, are more than eighty per cent water. At the end of the book you will find an appendix giving the composition of all the ordinary foods, and you should examine this and tell what nutrient is most prominent in the foods you eat most freely.

ARE THESE GOOD FOODS? WHAT DOES EACH CONTAIN IN LARGEST MEASURE?

Another substance that is absolutely necessary to the life and work of the cells is oxygen, which we get

from the air. If the supply of oxygen is cut off from the body for only a few moments, the life fire dies out. How the necessary oxygen is supplied to the cells and what use is made of it will be told in another chapter.

A poison is just the opposite of a food. Instead of furnishing the body with nourishment, it interferes with the life and work of the cells, disturbing them in such a way as to cause sickness and death. A true food must not contain any substance that is in any way harmful to the body.

Poisons, the opposite of food.

There has been in recent years much discussion as to whether or not alcohol is a food. Alcohol, as we have already learned, paralyzes the cells that make bone and flesh. All the delicate organs by which the life work of the body is carried on are injured by it and hindered in their work. Not only are the organs injured and weakened by it, but the task of removing this injurious thing (for it is injurious) from the body adds greatly to their work.

No food prepared for us by Nature is composed solely of one of the nutrients that we have been studying. They are combined in the foods in the way in which they will best meet the needs of the body. We may dine with a king and have a very elaborate menu with the food prepared in many different ways, but we can not have in it more than these few simple nutrients that we have studied. On the other hand, we may eat

our meal by the roadside with a laboring man, and if he has in that meal all of these nutrients in the right proportions, our body will be furnished with nourishment just as well as though we had eaten with the king.

Health Problems

1. What changes are taking place in the community in which you live? Is the community *growing?* How can you tell?

2. Have you noticed how very hungry growing puppies and kittens are all the time? Explain. Is this true of all growing animals? Why?

3. Suppose one could eat no food, what would happen to him? Why? Would it happen more quickly if he had to work hard than if he were idle? Why?

4. Have you ever had a physician "take your temperature"? If so, why did he do it?

5. When one goes out into zero weather, how is his heat kept up to about 100°? What would happen if it should drop a few degrees?

6. Think of some way to prove that the cells feed on the food taken into the body.

7. Are you more hungry when you work or play hard, or when you are out in the cold much, than when you live in a warm house all the time and do no work? Explain.

8. It is said that an apple, or a kernel of corn, or a nut is a sort of storehouse of light. From where does the light come?

9. Imagine that you are talking to a person who does not see that plants take materials from the air and the earth and make them into food. How could you make it so clear that he could not help but see it?

10. In what way, or by means of what organs, does the plant get its materials from the air? From the earth?

11. Make a list of common articles of food which contain starch, protein, fats, sugar.

12. Bring to the class small samples of the different kinds of sugar.

13. Can you tell starchy foods, fats, foods rich in sugar, and those rich in protein by the sense of taste alone? Explain.

14. Should a growing boy eat more of eggs, peas, beans, cheese, and the like than a full-grown man who is doing very little muscular work? Why?

15. Show by an experiment that a potato, or an apple, or a cucumber is largely water.

Review Questions

1. What is necessary that a living thing, plant or animal, may grow?

2. What do living cells need in order to maintain their life?

3. Why is the living body both like a house and like a machine?

4. What is the meaning of the "vital fire"?

5. What is the normal temperature of the body?

6. How is heat produced in the body?

7. What is the difference between the burning of fuel in the human body and the burning of fuel in a stove?

8. How do the cells get the energy for their work?

9. What happens in the body when work is done? Show that the body at work is something like a locomotive pulling cars.

10. What organs of the body are constantly at work?

11. What two things does food supply to the body?

12. What must happen to the material coming from the earth, the air, and the water before it can be used by animals as food? How does a plant make starch, for instance?

13. What is the difference between a piece of bread and a piece of coal so far as the body is concerned?

14. What is a nutrient? Name a number of nutrients.

15. Which nutrient supplies the building material for the body? Which warmth and power to work? Which the material for making bones, teeth, and such parts of the body?

16. Which is the most abundant of the nutrients?

17. Where is starch found abundantly? Discuss starch as a food.

18. In what fruits and vegetables is sugar found? Name the kinds.

19. In what foods are the fats found? Proteins?

20. What are the uses of carbohydrates and fats in the body? Of proteins?

21. Which of the classes of nutrients does the growing animal need especially?

22. Mention the minerals which are needed in the body. In what foods are they found?

23. What is oxygen? What happens to the body if the supply of oxygen is cut off even for a moment?

24. How does a poison affect the body? Is alcohol a food or a poison?

CHAPTER III

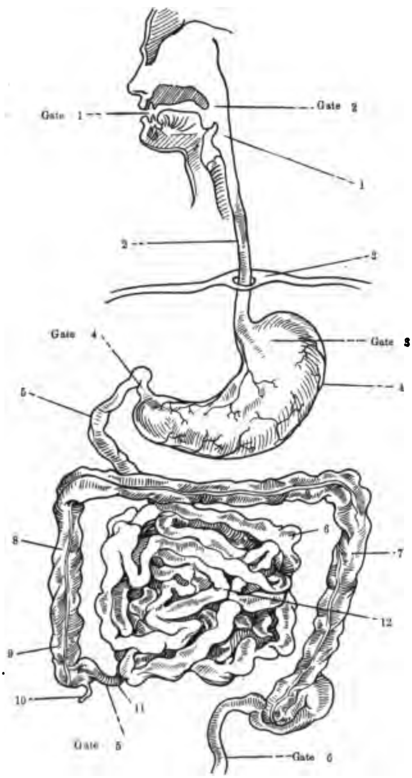
How Food becomes Living Tissue

The food substances or nutrients about which you have been learning can not be taken up just as they are used by the cells as food. A great deal of preparatory work is necessary. This work of preparation is called digestion. We have already seen how the work of the body is divided up among the different groups of cells that form the organs of the body. The groups whose work it is to prepare the food are called the digestive organs.

If you have ever visited a large bakery establishment, you have seen how the work is divided up among the different workers. One attends solely to the mixing and kneading of the dough, which is then passed to another who spends his time in rolling it out to the required thickness. Another worker then takes it and cuts it into pieces of the right size and shape and passes it to yet another who superintends the baking. In like manner the food you eat is passed from one to another of the cell groups called the digestive organs, and each group has some special part of the work of preparation, that we call digestion, to perform.

The food canal.

There is a long tube in which the work of digestion takes place, and this is called the alimentary canal or food tube. Aliment means food, and the alimentary canal is simply the food channel in the body. It is from twenty-five to thirty feet long and is lined throughout with fine pink skin called mucous membrane, which you can see in the mouth. This is kept always moist, so that the food may easily be moved along it.



START WITH GATE I, AND SEE IF YOU CAN TELL WHAT HAPPENS TO THE FOOD AS IT PASSES THROUGH EACH OF THE ORGANS OF DIGESTION.

The cell groups whose work it is to prepare the food are stationed at various places along the route that the food must travel, just where their services are needed. Each group prepares a special kind of fluid or juice which it pours out upon the food. These fluids are called the digestive juices. There are five digestive

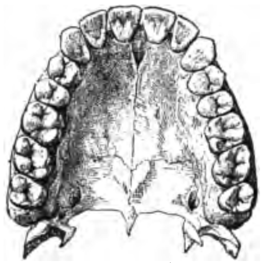
organs, and so there are five different kinds of digestive juice.

There are no openings in the alimentary canal, except at the entrance to the body and the exit from it. All the food, therefore, must be soaked up or absorbed by the walls of the canal in order to pass through it into the body for the use of the cells, which can take their food only in a liquid form. Most of our foods consist of solid particles which do not dissolve in water. Mix some sugar with a glass of water, and you will find that after a few minutes the sugar has seemingly completely disappeared. It is dissolved in the water, and you can detect its presence only by the taste. If you treat a piece of bread in the same way, you will see that it does not dissolve in the water but only mixes with it. If you strain the water containing the sugar through a fine sieve or cloth, both sugar and water will pass through together and there will be nothing left in the cloth. But if you strain in the same way the water with which the bread has been mixed, the water will pass through the cloth but most of the bread will remain behind.

Digestive juices.

The work of digestion is simply the work of changing the insoluble (Look up the meaning of insoluble) substances of the food into substances that are readily dissolved and so will pass easily through the walls of the food tube into the blood.

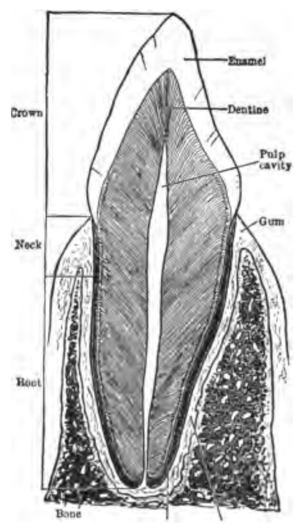
At the very entrance of the food canal is a station



THE PERMANENT TEETH, UPPER JAW.

The first step in digestion.

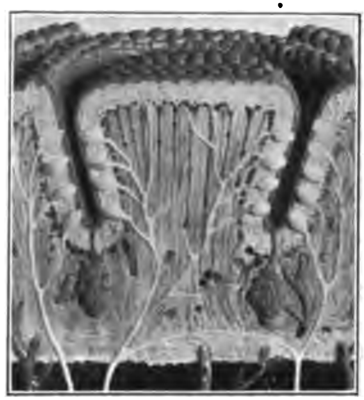
where the food must tarry for a while and be worked over before it starts on its journey through the body. This station is the mouth, the first of the digestive organs. The work done in the mouth, as we learned in *Health Habits*, is of the utmost importance because all the rest of the work of digestion depends upon thorough preparation being given to the food in the mouth.



SECTION OF A CANINE OR CUSPID TOOTH.

An important part of this work is the chewing or mastication of the food, which is done by the teeth. An infant is born without teeth. Between the ages of seven months and two years the temporary or milk teeth, twenty in number, make their appearance. By the twelfth year these temporary teeth have given place to the permanent set. A complete set of permanent teeth in an adult consists of thirty-two teeth. Each jaw contains four front teeth, called incisors or cutting teeth; two cuspids, one on each side of the

incisors; four bicuspids, two on each side; and six double teeth, three on each side, called the molars or grinding teeth. The purpose of the front or single teeth is to cut or bite the food, and the work of the double teeth is to crush or grind it into a pulp, the condition in which it should be before it is swallowed.



TASTE BUDS IN THE TONGUE.

The teeth are helped in the work of mastication by the tongue, which moves the food about, passing it from side to side of the mouth until it is all thoroughly chewed. In the tongue also are taste buds, of which we have learned, by which the different flavors in foods are detected.

The work of the saliva.

The work of mastication is also assisted by the saliva, the first of the digestive juices to be poured out upon the food. This moistens and softens the food, so that it is more easily made into a creamy pulp.

The saliva does much more to the food than merely to moisten it. If you chew a hard crust of bread for a long time, you will notice that after a while it becomes quite sweet to the taste. This is because some of the starch has actually been changed by the saliva into the kind of sugar called maltose.

The groups of cells which form the saliva and pour it on to the food are called *salivary glands*. Tell where these are situated, and the duct or tube through which the fluid is poured into the mouth. The glands of the digestive organs make substances that can be absorbed and used by the body. The substance manufactured by the salivary glands changes starch into sugar.

Saliva is formed and poured out each moment in quantities exactly suited to the nature and quantity of the food that is being chewed. If the food is already moist, the quantity of saliva produced will be very small. Why? When liquid foods like milk are taken, little or no saliva will be produced. Dry and highly flavored foods cause the salivary glands to pour out an abundance of saliva. Why? Food containing starch, which needs an abundant overflow of saliva, should of course be eaten *dry* and *should be thoroughly chewed. It is very necessary that the food should remain in the mouth long enough for a sufficient amount of saliva to be poured out upon it, and that it should be so thoroughly chewed that the saliva will become mingled with every part of it.*

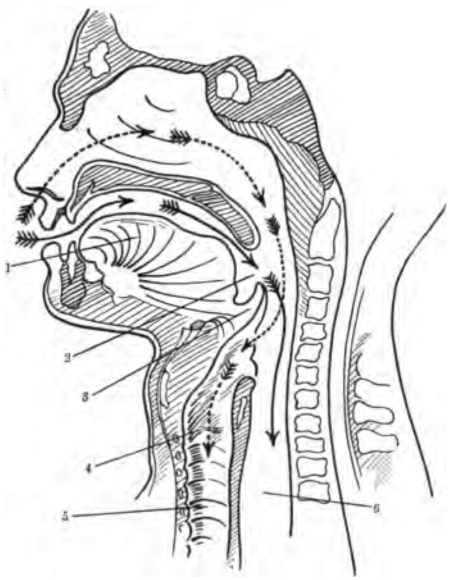
Try this: Add a teaspoonful of saliva to a tablespoonful of paste prepared from corn starch, thoroughly mingling the saliva with the paste. If this is kept warm, at a temperature of about blood heat, in a few minutes the thick paste will have become almost as thin as water, and in a short time a sweet taste may be readily detected. What change has occurred?

The process of starch digestion is not confined to animals alone. Most plants are capable of transforming starch into sugar. This change always takes place in the ripening of fruits. The starch of the green apple, for example, is changed into the sweet, wholesome flavors found in the ripe fruit. By a similar process, the starch stored up by the roots of the maple tree in the fall is in the spring converted into sugar and carried up in the sap. It is in this way also that the honey of plants is formed to be deposited in the flower cups from which it is collected by the bee.

When the food has been sufficiently acted upon in the mouth, it is then passed on its way along the alimentary canal. The muscles at the back of the mouth seize the food and carry it into the gullet or esophagus, — the name given to the nine inches of the food canal that connects the mouth with the stomach.

The muscles at the back of the mouth seem to act as gatekeepers to guard the entrance to the esophagus. At frequent intervals during mastication, they move the food forward in the mouth, thus keeping it there until it has been thoroughly chewed, when they are ready to let it pass on. The food then seems to "swallow itself," without any effort on our part. People very often *force* the food out of the mouth into the esophagus before it has had the proper mouth treatment. If the act of swallowing requires a conscious effort, we may be sure that the food has not been long enough in the mouth.

The esophagus is not a hollow tube through which the food is dropped into the stomach. The walls of the entire alimentary canal are composed in part of muscles, arranged in such a way as will best assist the work of the different digestive organs. By means of the muscles in the esophagus, the food is moved along until it reaches the second food station, — the stomach.



TRACE THE FOOD INTO THE ESOPHAGUS.

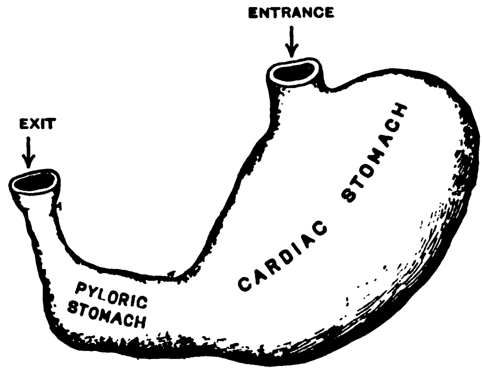
1, tongue; 2, pharynx; 3, epiglottis; 4, larynx; 5, tracheæ; 6, esophagus.

To form the stomach, the food tube is widened into a broad pouch, as shown in the picture. At each end of the pouch is a strong circular muscle to guard the entrance and the exit. The entrance is called the cardiac opening, and the exit is called the pylorus, meaning the "gatekeeper." The large end of the stomach near the cardiac opening, where digestion chiefly takes place, is called the cardiac end; the lower and narrower end, which is chiefly composed of very strong muscles, is the pyloric end.

Even before the food reaches the stomach, a very important work of preparation has been going on there. Nature has installed in the body, to help on the work of digestion, a kind of signaling system by means of which the digestive organs are given notice when food is to be expected. The cell workers then at once begin active preparations for their work.

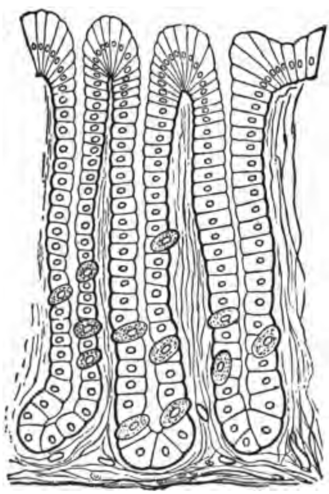
Stomach digestion.

You have noticed how, at the mere sight or odor of appetizing food — when you smell a good dinner cooking, for example — the mouth begins to "water." This is because a sort of telegraphic message has been sent from the brain to the salivary glands, and they have immediately begun to pour out a quantity of saliva in readiness for the food that is expected. Something of the same kind takes place also in the stomach. A Russian scientist, Professor Pawlow, made many experiments upon dogs and men by means of which he discovered some very interesting things about the work of digestion, especially that part of the work that is done in the stomach. He made an arrangement by



THE TWO PARTS OF THE STOMACH AND THE ENTRANCE AND EXIT.

which he could actually see into the stomach of a dog and find out exactly what took place there. When the dog was hungry, the mere sight or smell of food caused the stomach, as well as the mouth, to secrete its digestive juice, and this continued all the while the food was being chewed. By the time the food actually reached the stomach, there was a quantity of digestive juice ready for it.



THREE GASTRIC GLANDS (CARDIAC PORTION OF STOMACH).

The digestive juice that is poured upon the food while it is in the stomach is called gastric juice. It makes its first appearance upon the walls of the stomach in little drops, like tiny beads of sweat upon the skin when the perspiration starts. As the quantity increases, the drops run together and trickle down the sides of the stomach in little streams. The lining membrane of the stomach, seen under a microscope, is found to be crowded into minute openings. Each of these openings is connected with a narrow tube which extends into the walls of the stomach, making a kind of pocket. This little pocket is lined with living cells, which during digestion are actively at work making the gastric juice.

The gastric juice has no action upon starch, sugar, or fats, but only digests some of the protein of the food. There are two digestive substances made by the gastric glands, — pepsin and rennin, which are called ferments. The principal work done in the stomach is to liquefy the food. The rennin in the gastric juice has an interesting work to perform in connection with the digestion of milk. If milk were to remain in the liquid form in which it is swallowed, it would pass quickly out of the stomach without digestion. The rennin changes the milk into insoluble curds, and the proteins which it contains can then be worked upon by the pepsin. If the curds are hard and tough, the work will be harder and the milk will not be so well digested. For this reason it is not a good thing to swallow milk rapidly, in large quantities, as one does water. A nursing babe takes the milk in small quantities. This is the natural method of eating milk, in small sips, which will then form only small curds, which can easily be acted upon by the gastric juice.

The flow of the gastric juice is, like that of the saliva, regulated in a most exact manner, both in quantity and quality, to suit the foods eaten. Foods containing a large amount of proteins call forth an abundant flow of gastric juice, whereas starchy and fatty substances, which are not digested in the stomach, do not excite the gastric glands to lively activity. Why?

The work of protein digestion which goes on in the

stomach requires acid. Some of the gastric glands pour out a very strong acid called hydrochloric acid. This acid, while it assists the work of stomach digestion, puts an end to the work of starch digestion which was begun in the mouth by the saliva mixed with the food. As soon as the food becomes thoroughly mixed with the gastric juice, which is about an hour after it enters the stomach, the digestion of the starch, which has been going on up to that time, ceases. The acid in the gastric juice also does the important work of destroying bacteria or germs that get into the stomach through the mouth. So the stomach is a kind of disinfecting room for protecting the body against germs.

We found in the mouth not only the chemical action of the saliva, but also the muscular action of the jaws and the tongue. The work of the stomach is also assisted by the muscles. Next to the lining membrane which contains the gastric glands is a coat of muscular tissue. By contracting these muscles, the stomach is able to change its size and shape and to produce a sort of *kneading* action upon the food, thus softening it and thoroughly mingling it with the gastric juice. This work is kept up until the whole mass is soft and is something like a thick soup.

As more and more gastric juice is poured into the stomach, the food there becomes more and more acid. This acid urges the muscles of the stomach to work with greater and greater vigor. The gastric acid also causes the pylorus to open when the food has been

properly acted upon by the stomach juices. The pylorus does not allow food that is not in proper condition to pass. Any solid particles that get down near the exit are pushed back by the gastric muscles to the cardiac end of the stomach for further digestion. The food begins passing from the stomach within a few minutes after taking a meal. At brief intervals the pylorus opens and passes out a small amount of liquid food. At the end of four or five hours, the stomach is completely emptied.

When the food passes through the pylorus, it enters the next and most important of the digestive organs, the small intestine, which is the third food station. The contact of the acid liquid with the mucous lining of the intestine causes the pylorus to close. The action of the gastric acid in both opening and closing the pylorus is one of the most remarkable and interesting things known about the body.

This small intestine is a slender tube, about twenty feet long, that passes from the stomach to the large intestine or colon. You can see in the illustration the curious way in which this long tube is coiled and packed in the part of the body it occupies.

Digestion in the small intestine.

We have already studied the work of two of the five digestive fluids. Which two? The three remaining juices are poured upon the food while it is in the small intestine.

One of these is poured out by the intestine itself and is called intestinal juice. The other two are

manufactured by two large organs lying near the stomach, the liver and the pancreas.

The fluid manufactured by the liver is the bile, which is stored up in a sack or pouch called the gall bladder. When needed for the work of digestion, the bile is poured through a duct into the small intestine, in much the same way as the saliva is poured out into the mouth. The duct enters the intestine a few inches below the stomach.

WHERE THE INTESTINAL JUICE IS MANUFACTURED.

Up to this point in the work of digestion, the starch has been acted upon by the saliva, and the proteins by the gastric juice, but no change has taken place in the fats, except that they have been melted by the heat of the body. The special work of the bile is to aid in the digestion of the fats. Fats are first emulsified or subdivided into particles so small that they may be absorbed. An emulsion may be made experimentally by mixing olive oil with a quantity of gum water. Add

to one part of mucilage three or four parts of water, shake until well mixed, and then add one part of oil. Note that when the oil is first added, the two liquids remain distinct. Shake thoroughly for a minute, when it will be impossible to distinguish the oil from the gum water. The result will be a creamy liquid, which, added to water, produces a mixture having a milky appearance. If allowed to stand for awhile, the emulsion will rise to the top as cream rises upon milk.

Next the fats are changed into soaps by combining with the alkaline substances of the bile and pancreatic juice. In the form of soaps, the fats are soluble and can be absorbed. After absorption, the soaps are changed back into fats.

The digestive fluid formed by the pancreas, the pancreatic juice, enters the intestine at the same point as the bile. The remarkable thing about the pancreatic juice is that it does the work of all the other juices combined. It digests starch, like the saliva; it digests proteins, like the gastric juice; and it acts upon fats, as does the bile. Why should there be this arrangement in the food canal, do you think?

The work of the saliva ceases when the food becomes mixed with the acid juice in the stomach. When it passes out into the small intestine, the work of starch digestion is taken up again and carried on by the pancreatic juice.

The work of the gastric juice also ceases when the food leaves the stomach, because the acid which is

necessary for protein digestion is neutralized by the alkaline juices of the intestine. The work that was being done by the pepsin is then taken up and completed by the pancreatic juice.

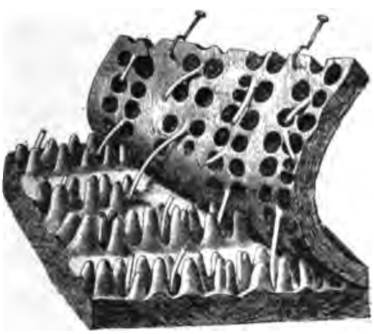
The pancreatic juice is of great importance, because, as we see, it acts upon each of the three great classes of food substances, — carbohydrates, proteins, and fats. The other two juices in the small intestine, the bile and the intestinal juice, are simply aids to the work of the pancreatic juice.

The powerful pancreatic juice is poured out near the entrance to the small intestine, so that the digestive work to be done there is well started. It is completed by the intestinal juice, which is poured out along the whole twenty feet of the intestine and does much the same kind of work as the pancreatic juice. In addition to this, the intestinal juice has also the power of digesting cane sugar, which is the only kind of sugar that needs digestion.

While this important work of digestion is taking place in the small intestine, another interesting work of equal importance is being carried on there. If we examine the mucous membrane lining of the small intestine, we find that it contains, like the stomach, the little tubelike glands that made the digestive fluid and in addition to these a thick covering with tiny fingerlike projections which give it a velvety appearance. These villi, as they are called, have a very important work to do. They suck up the digested

food, much as the tiny rootlets of a plant suck up its nourishment from the soil. Indeed, the villi may be properly regarded as the "roots" of the body, while the liquid food which bathes the villi is the "soil" out of which the body draws its sustenance just as a tree or plant grows out of the earth.

We have already learned that all the digested food must be absorbed through the walls of the alimentary canal. The absorbing surface of the small intestine,



WHAT WORK DO THESE VILLI PERFORM?

DO YOU SEE HOW GREATLY THESE VILLI ENLARGE THE ABSORBING SURFACE OF THE INTESTINE?

where this work of absorption chiefly takes place, is very greatly increased by the villi and by folds in the lining membrane. The length of the small intestine is about twenty feet, and its circumference about three inches, dimensions which would give an absorbing surface of about five square feet. By the villi and the folds in the mucous membrane it is increased more than fivefold and gives an absorbing surface of many square feet.

The work of digestion and absorption going on in the small intestine is greatly helped by the muscles, as we have found to be the case in the mouth and the stomach. Like the stomach, the intestine has a coat of muscular tissue next to the mucous membrane. By the work of these muscles, the food is kept in constant motion, so that it becomes thoroughly mixed with the digestive juices, and the villi are dipped down into all parts of it to suck up the digested portion. From the stomach downward, the food is moved along the alimentary canal by successive contractions of the muscular walls of the intestines. These contractions are known as peristaltic movements, and they occur with great regularity during digestion. You can illustrate intestinal movement by filling some rubber tubing with water and tying both ends. Press the tube with the fingers of each hand grasping the tube, slowly and alternately. Peristaltic movement may be illustrated by running a finger slowly along the whole length of the tube.

The last food station.

The indigestible materials in the food, as well as the wastes formed during digestion and any of the digested food that still remains, is carried from the small intestine into the large intestine, which is not a digestive organ but simply a reservoir, where the food remains until all of the digested portion has been absorbed from it. As the liquid food is sucked up, the residue becomes more and more solid, and the wastes are moved onward until they are ready to leave the body.

To prevent the wastes from passing back, nature has provided at the end of the small intestine a check valve known as the ileocecal valve. This valve behaves very much like the pylorus. It passes the food residues and wastes into the colon, and then prevents their return to the small intestine. Sometimes this valve becomes damaged, and then the filth from the colon passes back into the small intestine, and great harm results.

If the work of digestion has been well done, these wastes will pass naturally out of the body at regular intervals. The emptying of the bowels takes place normally about once in twenty-four hours, at about the same time each day. It is very easy to form habits in this respect and of great importance that the habits we form should be good ones. It is just as important to discharge from the body the waste products as it is to take in a fresh supply of food. If the drains of a city become choked up, the health of the community is very likely to suffer. The health of the cell community which inhabits the human body depends upon the prompt removal of all wastes.

The work of microbes.

Besides the changes which are made in the food in the intestines by the digestive juices, there are other changes which are produced by microbes. We saw that the acid gastric juice destroyed the germs that found entrance to the healthy stomach. The intestinal juices are not acid, so the germs have a chance to grow and multiply there. They gradually increase in number from the stomach

to the large intestine, which is a very favorable breeding place for germ colonies. Some of these are not only harmless, but even friendly and useful. Others, however, cause the contents of the intestine to decay or putrefy and give off very offensive odors and poisonous products that are most injurious to the cells. In a person who is in perfect health and who lives wholesomely, these poison-forming germs are not present in sufficient numbers to do harm. But under certain conditions, especially in one who lives unhealthfully, they may multiply to a very great extent, and the poisons they produce may be a cause of serious disease. In all cases, the prompt removal of the waste matters in the intestine is a matter of great importance. Headaches and general bad feelings and bad temper may result from the body's being poisoned by the waste matters that have been allowed to remain in it beyond the natural time.

The digested food which has been sucked up by the walls of the alimentary canal, in much the same way as a sponge absorbs water, is in the process of absorption changed into blood. It then passes into the blood vessels with which the walls of the canal are richly supplied.

Before the food supply in the blood passes to the heart, from which it is to be distributed to the body for the use of the cells, it must pass to the liver for its final inspection and preparation. Some starch, which during digestion was converted into sugar, is changed

back by the liver into a kind of animal starch called glycogen. In this form it is stored up in the tissues of the liver until it is needed for body work or heat production, when it is given out as needed, having been first changed back into sugar. In this respect, the liver might be looked upon as a sort of living, automatic stoker, which supplies fuel to the body as needed, just as devices made for the purpose supply coal as needed to the furnaces of steam boilers.

The liver also acts as a kind of food inspector for the purpose of protecting the body against poisons. When any metallic poison such as mercury, lead, or arsenic is taken into the blood, the liver absorbs and retains as much as possible of the poison and so protects the rest of the body. Vegetable poisons are also destroyed by the liver.

We should notice as we pass that not all of the food supply passes through the liver on its way to the heart. A comparatively small portion, especially that which contains the digested fats, is taken from the intestines by small vessels called *lacteals*, which carry it to a duct called the thoracic duct, by which it is carried directly to the heart.

Making blood into tissues.

The final act of becoming nourished is the making of the liquid blood into solid tissues, a change exactly the reverse of that which takes place in digestion. Each tissue takes from the blood the material needed for its own uses and builds and repairs itself. So you see that assimilation, for

that is what this process is called, is something like creation. It is the building of tissues and organs out of the blood, the stream of life, which serves as a sort of circulating market, or, one may say, a canal along which the nutrient elements prepared in the digestive organs are conveyed to the places where they are needed.

Let us now retrace briefly the chain of events which follow each other in the work of digestion, from the time the food enters the body until it becomes a part of it, built into its living tissue.

In the mouth the food is ground and crushed into a pulp and thoroughly moistened with saliva, which begins the digestion of starch.

It then passes through the esophagus into the stomach, which is a sort of storehouse or preparatory chamber, where it is disinfected, and the work of protein digestion begins.

Having been thoroughly worked upon by the gastric juice and the stomach muscles, it is passed out through the pylorus into the small intestine. Here the bile formed in the liver is poured upon it for the digestion of fats. The pancreas also contributes its powerful juice, which works upon all three classes of foods, starches, fats, and proteins. The intestinal juice also does much the same work as the pancreatic juice, and in addition it digests cane sugar.

By means of the villi lining the intestinal wall, the digested food is absorbed, as the food is worked upon

and carried along by the muscles to the large intestine, where the absorption of the digested food is completed and the waste matters are discharged from the body.

The absorbed food is carried by the blood vessels to the liver, which puts the finishing touches on the proteins or building foods, and regulates the supply of fuel foods to the body, storing up digested starch in the form of glycogen. The liver also extracts poisons and changes them into less harmful substances.

The food supply then passes to the heart, from which it is sent out into every part of the body and used by the cells, for the building up of the living tissues and organs which compose the body.

Health Problems

1. Mention at least ten insoluble articles that can be digested and explain how digestion is possible.

2. What is the meaning of canal? Is it proper to speak of the tube that carries the food through the body as a canal? Why?

3. Which of your permanent teeth have you now? Which of your baby teeth are you losing? What permanent teeth must you still get?

4. Just where on the tongue are the taste buds situated? What would happen to one if his taste buds should be destroyed?

5. Have you ever had a sickness during which your mouth seemed "dry" so that you could not moisten your food well? How did the food taste? Explain.

6. Do people who masticate their food thoroughly get more pleasure from it than those who bolt it, or swallow it in a half-masticated condition? Explain.

7. Have you ever noticed that when you are sick food will not make your mouth water? What is the explanation of this?

8. Mention some appetizing foods. Mention some that are not appetizing. Which can you digest most easily? Why?

9. Do you know why people often crave acid drinks, as lemonade and the like? Would you expect these to assist digestion? Why?

10. Write a little story about: "What Happens to a Mouthful of Bread." Take it right at the start and show what interesting things occur until the body is through with it.

Review Questions

1. What work is necessary in order to prepare nutrients so they can be used by the cells as food?

2. Compare the organs used in digestion with the workers in a bakery establishment.

3. What is the name of the canal through which the food passes in the body? What are its principal parts?

4. What are the digestive juices? How many kinds are there?

5. Of what does the work of digestion consist?

6. What does it mean to masticate one's food? Why is mastication necessary?

7. How many teeth does an adult have? Describe each kind and tell for what it is used.

8. What is the saliva, where is it formed, and what is its use? What is necessary in order that saliva may get in touch with one's food?

9. What are the enzymes and for what are they used in the body?

10. Can starch be digested by plants as well as by animals? How can one tell?

11. If one has poorly masticated his food, will he have to make an effort to swallow it? Why?

12. How is the stomach formed?

13. What is the meaning of pylorus?

14. Describe the "signal system" which nature has provided in the body to help digestion.

15. What happens in the mouth when one sees or smells appetizing food? How does this help digestion?

16. What juice is mixed with the food in the stomach?

17. Suppose you should examine the lining membrane of the stomach, what should you see?

18. How is the amount of gastric juice prepared in the stomach adapted to the needs of digestion? What is the use of this acid?

19. Describe the muscular action of the stomach. How does this help digestion?

20. Describe the work of the pylorus.

21. How long does it take ordinarily for a meal to pass out of the stomach?

22. Where is the small intestine? How many juices are poured out on the food from the intestine?

23. What organs make the bile?

24. Where are the fats of our food digested? How are they digested?

25. What is the pancreatic juice? What foods will pancreatic juice digest?

26. Describe the villi in the mucous membrane of the small intestine. What is their business?

27. What is the large intestine? How does it differ from the small intestine in its work?

28. Before the food in the blood passes to the heart, where must it go for final inspection?

29. Just what does the liver do to the food to make it ready for use by the cells? Why is it right to speak of the liver as a kind of food inspector?

30. What is the meaning of assimilation?

CHAPTER IV

Eating for Health and Pleasure

The only part of the important work of nutrition that Nature has left to us is the selection of the food and the preparation of it for digestion by thorough chewing. All the rest of the work is done for us, without any thought or effort on our part. Everything done in the process of digestion, however, is greatly influenced by the manner in which we do our part of the work.

As an aid to us in selecting the food and as an inducement to us to keep it in the mouth until our part of the work is well done, Nature has put into it all kinds of agreeable flavors. When we swallow our foods with little or no chewing, do you think we lose these flavors and miss the pleasure that Nature intended for us in eating and that is a great help to the work of digestion?

One of Professor Pawlow's interesting experiments proved that the amount and efficiency of the gastric juice depend very much upon the enjoyment of the food. The esophagus of a dog was divided and part of it connected with a tube. When the dog was fed, the food, instead of passing into the stomach, dropped

out through the opening into a dish. The dog, however, thought he was having a good meal, and the gastric juice immediately began to form in the stomach and continued to pour out as long as he kept on eating and enjoying the food. When he was given food that he did not like, however, there was no outpouring of gastric juice. Also when food was put into the dog's stomach through the opening, without his knowledge, little gastric juice was formed and the food lay there for hours undigested.

The digestion depends upon enjoyment of food.

The gastric juice that is poured out at the beginning of digestion, as the result of the enjoyment of the food, has been given the name of "appetite juice" and has been found to be the most powerful and active juice formed in the stomach. We can see from this that the more the food is enjoyed, the better it will be digested. If a person is not hungry and so does not relish his food, he will have no "appetite juice" to welcome the food in the stomach and to begin the digestive process.

Do you think it is of great importance that the food should be attractive to the eye and savory to the smell and taste? Why? Should each mouthful be kept in the mouth until all the enjoyment possible has been got out of it? Why?

Those who wish to keep the body in the best state of health should cultivate the habit of chewing the food until all the soluble parts have been dissolved. As a

rule, this will be until enough saliva has been poured out to extract from the food all the substances having any taste. In other words, we should chew the food until we have got all the taste out of it.

Mouth digestion we have found to be the first of a number of changes which take place in the alimentary canal. If the first step is imperfect, the succeeding steps are likely to be more or less defective. Stomach digestion can not be well performed unless mouth digestion is well done. As you know, the stomach has no teeth by means of which it can crush and grind any lumps of food that have been forced down into it. When the food is not thoroughly masticated, it must remain in the stomach longer than it should, while the stomach muscles try to perform the work that should have been done by the teeth. The gastric juice, which by its acidity destroys germs, after a time disappears. There is then no protection against germs that may enter the stomach through the mouth. The undigested material will afford food for the germs, and they will multiply very rapidly, causing the food to ferment or putrefy. The formation of large quantities of gases and acids results. Colic, biliousness, jaundice, and other serious maladies are caused in this way.

Some causes of indigestion.

The bolting of food, or swallowing it without proper attention to mastication, is a very injurious though common habit. Many of us are in such a hurry that we prefer to make use of soft foods of some sort that can be easily swal-

lowed without chewing. Moist foods such as mushes and soups cause the flow of only a small part of the saliva that is called forth by the same food in a dry state. It is therefore better that much of our food should be taken dry so as to compel thorough mastication.

What is likely to happen to one who gulps his food as this boy is doing?

It should be remembered, however, that in taking starchy foods which are already moist, mastication is all the more necessary for the development of the amount of saliva required for the digestion of the starch. Even such liquid foods as vegetable soups or gruels should be held in the mouth until thoroughly mingled with the saliva. In the feeding of horses, farmers recognize the value of thorough mastication. To secure this, they frequently put into the manger along with the food a quantity of small stones. The animal is then compelled to take the food into its

mouth in such small quantities that hasty eating is prevented.

Drinking at meals usually leads to bolting food. These two evils are closely connected. Liquids taken with the food diminish the flow of saliva and so interfere with the work of digestion. Why? Very cold liquids are especially bad, because they lower the temperature of the stomach too much and put a stop to the digestive process. A temperature of 100 degrees is required for digestion. It has been observed that a glassful of ice water lowered the temperature of the stomach contents to 70 degrees and that more than half an hour passed before the normal temperature was regained. Hence the whole digestive process was checked for half an hour. An equal quantity of ice-cream would have produced a much more marked effect.

Hot drinks, while they excite the stomach, tend to relax and weaken its muscles and lessen digestive vigor. They also destroy certain useful elements in the saliva. The highest degree of digestive activity seems to be secured by the use of food at a temperature a little below that of the body, or at the ordinary temperature.

The best time to take liquids is at the close of the meal, when there will be little danger of drinking too much. Fruits eaten with the meal, or at the close, lessen the necessity of drinking too much at meals.

It is not well to try to get along without any liquids when we eat a meal of solid food. Experiments have

shown clearly that a glassful of water, not too cold, taken with the meal, helps digestion and enables one to get more out of his food. A good plan is to take a glassful of cool water a half hour before a meal, and a glassful at the close.

A variety of foods is necessary to assist the appetite, upon which good digestion so largely depends. The stomach may, however, easily be overworked by a great variety of foods taken at a single meal.

Simplicity is very important for good digestion. The natural appetite is easily satisfied with a small number of foods, simply and wholesomely prepared. Animals such as the sheep, the goat, and the cow, which in the course of a morning's grazing may swallow one hundred different kinds of herbs, have very complicated stomachs with four compartments. Some fishes which live on others are provided with more than half a dozen stomachs in which to do their digestive work. Man, with a single, simple stomach, often sits down to a feast which would tax the digestive power of an animal having many stomachs.

It is important that the food should be varied from day to day or at different meals as each food supplies the body with some special useful product.

A tired stomach.

The digestion of a meal requires at least several hours. As you might expect, the stomach then needs a period of rest before it is ready to undertake the digestion of another meal. Of course, if food is taken too frequently, the stomach

will suffer sooner or later, because it will have no rest. You know that the muscles of the arm become wearied by constant exercise and so do the stomach muscles, which are actively exercising during digestion. "A tired stomach is a weak stomach." When the stomach feels "faint," rest is what is needed, yet many people insist on putting more food into it, thus compelling it to work when it ought to be allowed to rest. Suppose this is kept up; what may happen to the stomach? Have you known of such cases?

If a meal is taken before the preceding meal has been digested and has passed from the stomach, the portion remaining becomes mixed with the fresh food, and being too long in the stomach, it is liable to ferment. Thus the whole mass of the food is more or less spoiled and rendered unfit for the nourishment of the body. What is still worse, the stomach is liable to suffer great injury from the acids developed.

The number of meals needed daily depends upon the age and upon the nature and quantity of the food taken at the meals. A little baby, that takes only a small quantity of easily digested food at each meal, requires food at frequent intervals. As it gets larger and its meals increase in size, the interval between meals should be lengthened. By the time it gets its teeth and is able to eat solid food, three meals a day are quite sufficient.

The great majority of people in the world eat only two meals a day. This is the custom of the natives

of India, of South America, and of many semi-civilized nations. Among savage tribes, one meal a day is the prevailing custom. Though the Eskimo hunter sets out fasting in his Kajak on a day's hunt at break of day, he eats nothing until after he returns from his perilous work just before sunset. The ancient Greeks, Hebrews, and Persians ate but two meals a day. It is therefore evident that one can be well nourished on two meals a day. In modern times thousands of persons have adopted this custom with benefit to themselves.

PERSONS WHO DO HARD MUSCULAR WORK MAY EAT MORE FREQUENTLY THAN THOSE WHO DO NOT DO HARD WORK.

If more than two meals are needed by any class, it is by those who are engaged in severe muscular labor. Such persons are better able to digest a third meal than those whose work is mental or sedentary, as we say. If a third meal is taken by mental workers, it should be very light. All that has been said about too frequent eating shows that the practice of eating sweetmeats, confectionery, nuts, and such things between meals

is a very harmful one. It is a certain cause of indigestion, for no stomach can long endure such treatment. By forming this bad habit in childhood, many persons lay the foundation for much suffering from dyspepsia later in life.

Hindrances to digestion.

Digestion can not be well performed during sleep. A sleeping stomach is very slow in its work. The gastric juice is *small* in quantity and *poor* in quality. Bad digestion and restless sleep are the result of late eating. Through the bad habit of eating just before retiring, many persons suffer from sleeplessness, bad dreams, and similar troubles and arise in the morning very dull, because the work of nutrition has been hindered.

Usually no food should be taken within four hours before retiring, except by young children. This will allow time for the stomach to finish its work and pass the food into the small intestine. Then the work of digestion may be completed without disturbance. If any food at all is taken shortly before retiring, it should be only ripe fruit, or fruit juice, which does not require digestion, but is ready for immediate use.

Another cause of indigestion which is closely related to those we have studied, is *irregularity* in the time of meals. Our bodies try to form regular habits. This is especially true with respect to digestion. If a meal is taken at a regular hour, the stomach will become accustomed to receiving food at that hour and will be prepared for it. If meals are eaten irregularly,

the stomach does not know what to expect. It is taken by surprise, so to speak, and is never in a proper state of readiness for the prompt and perfect performance of its work. You must remember that the action of the digestive organs, like that of all the other organs, is rhythmical, — that is, it takes place at regular intervals or periods. It is far better, however, to omit a meal than to eat when not hungry, or to introduce into the stomach a new supply of food when it already contains some in the process of digestion, or before it has been given opportunity to rest.

Violent exercise, either just before or just after eating, is a hindrance to digestion. It takes the blood away from the stomach to other parts of the body, and so the stomach is deprived of the energy needed for good digestion.

For the same reason it is not a good thing to eat when one is very tired. The energy needed for the work of digestion is lacking in a person who is in an exhausted condition, and the food is likely to remain in the stomach for some time undigested. If food is needed by one who is very tired, only a small quantity of an easily digested kind should be taken. Nitrogenous foods, such as meat and eggs, are especially harmful to a person who is very tired. Thin, well-boiled gruel, a cup of vegetable broth, or better still, a glass of fruit juice, are best for tired people. Fruit juices contain food ready for absorption.

Not only should one not eat when he is tired; but

it will be even worse if he eats when he is excited or angry or irritated in any way. Why? Professor Pawlow found that no gastric juice was formed in the stomach of a dog if the animal was annoyed or irritated while eating. Some experiments made by Professor Cannon of Harvard University show that digestion in the small intestine, as well as in the stomach, is greatly influenced by the mental state. He placed a cat under the X-ray, so that he could see the stomach and the intestine. The cat was given some bread and milk containing bismuth, which made the food visible under the X-ray. The digestive juices began to flow; the stomach and intestines began their muscular work, and everything was going on nicely, and the cat was purring in comfort after her good meal. When something was done to make the cat nervous, the purring ceased, and all the digestive work began to slow up. If she became very much excited or angry and began to spit, the digestive juices ceased to flow, the muscles stopped work, and everything was at a standstill. The work of digestion stopped entirely until pussy was stroked or petted into a good humor. This shows us that the happy, peaceful, satisfied state in which a cat is when she is purring is the most helpful to digestion.

How digestion is influenced by the mind.

The mind should be in a cheerful frame, especially while food is being eaten and digested. What sort of conversation should there be at the table? Arguments

or disagreements and everything of an unpleasant nature should be carefully avoided.

The ancient custom of having a jester at the table to make people laugh while eating was good for their health as well as their humor. "Laugh and grow fat" is an old maxim.

The normal guide.

A natural and healthy appetite is the best guide as to how much one should eat. If one eats in a proper manner, chewing every morsel until it is liquid, his appetite will guide him in the selection of the food needed and will recognize when he has had enough of protein, starch, fat, or acid. You already know something about the remarkable signaling system by means of which the digestive work is controlled. The regulation of the appetite is an interesting part of this system. There are in the brain certain centers which have been called "hunger centers." When the body is in need of food, a message is sent up to these hunger centers and, from them, transmitted to the mouth by the nerves of taste, creating a desire for food, that we call "appetite." When enough of a certain kind of food has been received into the body, the "hunger centers" are notified that no more is needed, and the appetite for that particular food is cut off. Pawlow's dogs continued eating with unabated appetite for hours at a time when their food passed into a dish instead of into the stomach. Since no food was received into the body, no message was sent up to the brain to cut off the supply.

When one bolts his food, he can not discover when he has had enough, for some of the food must get into the blood before the "hunger center" will ring the bell, so to speak, for the supply to cease. When one hurries food into the stomach, he gets more than he needs before the "hunger center" finds it out, and he stops only when he is so full that he can not take any more.

Waste in eating.

We can now see how some of the bad habits that we have been considering — eating too fast, drinking too much at meals, and taking too great a variety of food at a meal — lead to the further bad habit of eating too much. The digestive organs are then overtaxed to take care of a quantity of food that is not needed. Not only is there this waste of energy in digestion, but all food taken into the body beyond what is needed is not only of no use but it is actually harmful. If, in repairing a house, a great deal more material than is needed is carried into the house, it is only in the way of the workmen, and they have to spend their strength in carrying it out. It is just so with the little cell workers of the body. When more food is taken into the body than is needed for their work, it becomes simply so much rubbish that must be got out of the way as soon as possible. It puts an extra burden upon the cells to get rid of it.

The sense of taste was given to us to be our guide in supplying the needs of the body and not for our

gratification merely. When we eat things that are harmful to the body or eat too much even of what is good, because it pleases our taste, we are injuring the sense of taste, so that it will no longer be a safe guide.

If we know how to eat, and we do that in a proper manner, we know just how much to eat, the appetite will crave the right kind of food in the right quantities, and will make all the digestive juices needed for the digestion of the food.

Health Problems

1. How many minutes do you take for each meal? Do you know people who hurry through every meal as if they had to catch a train? If so, are they healthy and successful people?

2. Eat a slice of bread by chewing it until it swallows itself. How does it taste? Explain.

3. Put your hand into a bowl of ice water; how long can you endure it? How long could you keep your face in it? How do you think one's stomach would like to have a bowl of ice water poured into it?

4. Do you know people who have got in the habit of nibbling at food much of the time? Tell about such a person's health and his good feeling.

5. Look up the meaning of dyspepsia. Then make out a list of the eating habits one should form in order to avoid this disease.

6. How would it do for one to get into the habit of eating breakfast one day at 8 o'clock, the next day at 10 o'clock, the next day at 9 o'clock, and then go back to 10 o'clock and repeat the process? Would it make any difference if this irregularity occurred at dinner or supper?

7. How would it do to jump up from the table at dinner and run a race with a companion? Explain.

8. If people must quarrel, what time should they avoid doing it? Explain. What of telling the news of murders, floods, fires, and scandals at the table?

Review Questions

1. What has Nature done to induce people to chew food thoroughly?

2. Should food be attractive to the eye as well as to the smell and taste? Why?

3. How long should food be kept in the mouth?

4. What may happen in the stomach if food is not thoroughly chewed before it is swallowed?

5. Why do people so often bolt their food?

6. What is the danger in eating moist foods like mushes and soups? If one eats such foods, what special care must be taken with them?

7. How do farmers treat their horses to prevent them from bolting their food?

8. What is often the cause of drinking large quantities of liquids at meals? What is the harm of so doing?

9. What temperature is required for digestion? How will a glass of ice water affect this temperature?

10. What is the harm of drinking very hot drinks during meals?

11. If one must drink during meals, how should he do it?

12. Is a variety of food at a meal good for the health? Why?

13. Why is it harmful to take fresh food before the previous meal has been digested?

14. How many meals a day are necessary for people of different ages?

15. Is there any harm in eating just before going to bed? If food must be taken just before bed time, what should it be?

16. Is there any harm in eating at irregular times? Why?

17. Is there any harm in taking violent exercise before a meal? Why? What of eating when one is tired?

18. How does the mind influence digestion?

19. What are the hunger centers?

20. How can we tell how much we ought to eat?

21. What habits may lead one to eat too much?

22. How may one injure the taste so that it may not be a safe guide for him in eating?

CHAPTER V

The Blood

More than a century ago, a great English scientist, John Hunter, performed some interesting experiments. He cut all the nerve trunks that supplied the limbs of an animal and then watched the results. The limb was paralyzed, but the flesh remained warm, the circulation continued, the hair and nails grew as before, and so the limb remained alive. The muscles shrank for want of use, but otherwise no evidence of disease appeared. An experiment was then made in another limb. The arteries conveying the blood to the part were tied, while the nerves were left undisturbed. Note the different result: Within a few hours the limb became cold. It became also livid, purple, and finally black. Soon the flesh began to fall away. The limb had died and had become simply a decaying mass. These experiments clearly showed that it is the blood that maintains the life of the tissues through which it flows. The blood constantly replaces the worn-out cells and fibers, so that by its agency the body is continually renewed.

The eyes with which we look out upon the world to-day are not composed of just the same cells as those which pictured for our brain the happenings of the outer world a year or two ago. The muscles which

move us about, the brain and nerves with which we think and feel, are likewise new. All the soft parts of the body are so rapidly changed that the great mass of the body is renewed every few months or, at the longest, every few years. It is by means of the blood that this body rebuilding is constantly carried forward.

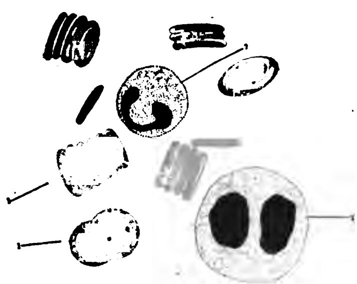
The blood has been called the "carrier" of the body. It receives the digested food from the alimentary canal and the oxygen from the lungs and carries them to the waiting tissues in all parts of the body. The tiniest cell, no matter how far removed from the great centers of life, receives its due share of nutriment through the medium of the blood. The blood might well be called a "traveling exchange," for in return for the new material which it supplies to the tissues, it carries away the cell wastes to the organs by which they are expelled from the body. Is this constant exchange of matter in the body essential to life? Why? Do you think that the more rapidly old material is carried away and new material deposited in its place, the more rapidly the wheels of life will turn and the more one will really live?

The blood cells, red and white.

As you look at blood it appears to be red, but when you examine it under the microscope, it no longer looks red. It is then seen to be filled with very small forms known as the blood cells or corpuscles.

The number of these cells is so great that a very small drop of blood contains more than five millions, and the

number contained in the body of an average man is twenty-five million of millions, — 25,000,000,000,000. In other words, a man has in his body twelve thousand times as many individual blood cells as there are people on the earth. The blood cells are so small that it takes from 2500 to 3500 to make a row an inch long; but their number is so great that the blood cells of a man arranged in a single row would reach four times around the earth.



BLOOD CELLS.
1, red blood cells; 2, white blood cells.

Each of these little cells is a distinct living creature, but its period of life is only about six weeks. Consider for a moment the significance of this. Twenty-five millions of million blood cells must be created every six weeks. This requires the making of blood cells at the rate of more than seven millions per second. At every tick of the clock, seven million blood cells die, on the average; and seven million more must be created to take their places. Do you see what a wonderful factory the human body is?

A close look at the blood cells under the microscope will show that they are of various shapes and sizes. The smaller ones are the most numerous. They have the shape of flattened, biconcave (hollowing in on both sides at the center) disks, and are of a faint amber

color. These are the oxygen carriers of the blood. They carry from the lungs to the tissues the life-giving oxygen upon which every function of the body depends. It is by means of a pigment they contain called hemoglobin, which gives to the blood its red color, that the red cells are enabled to carry oxygen.

The time occupied by the passage of the blood through the lungs is very brief, only a few seconds, and yet this is sufficient for the unloading of the poisonous carbon dioxide, which is received from the tissues, and the taking on of a fresh load of oxygen. The lungs may be regarded as the chimney of the body, — the carbonic acid gas is the smoke; and the oxygen, the air which comes in through the draught; thus the lungs serve the purpose of a draught as well as that of a chimney. Suppose that a stove were constructed with but one small opening for the entrance of air and the outlet for smoke. The fire might be started in such a stove, but it would quickly be smothered by the accumulation of smoke, which would prevent the entrance of fresh air. The same thing would happen to the body were it not for the red blood cells. These carry in the fresh air, the oxygen, and assist in carrying out the smoke, just as men might carry into a laundry buckets of pure water and carry out the dirty water resulting from the washing process.

The white blood cells show many different sizes and shapes. In the resting or quiet state, the white cells are transparent spherical forms, resembling jelly

drops, which float in the blood stream. They are able to move like the amœba by changing their form, — stretching themselves out into elongated shapes and gathering themselves together again like a worm.

The red cells do not leave the blood vessels, but the white cells have the power to pass straight through the walls of the capillaries, which are small blood vessels, leaving no gap or opening behind them. Just how they accomplish this is one of the mysteries of science.

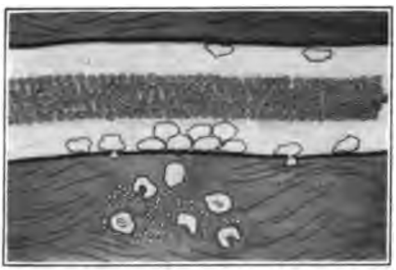
The white cells of the blood have been well called the "Army of the Interior," because they are the defenders of the body against disease and other dangers. Every human body is guarded and defended by a countless host of little living soldiers, some of whom guard the walls and fortifications, while others like "flying columns" move about freely to spy out the enemy and attack him at whatever point he appears. They seem to have no generals and no commander-in-chief, yet they act in unity and harmony that might well serve as a model to the great armies of the world. They possess powers superior to the most experienced veteran of any army. They never sleep, but keep constant watch day and night and seem to detect by instinct the approach of an enemy. They are able to change their form and take on that most suitable for their object. More wonderful still, they are able to penetrate vessel walls and other tissues without

difficulty. The law of their being is that they must conquer or die, and they frequently do lay down their lives in great numbers to save the body which it is their business to defend.

The defensive and healing power of the blood cells.

Each cell seems to have a will of its own and a peculiar intelligence by which it is unerringly led to the place where it is needed. Suppose, for example, a few germs are introduced into some transparent tissue (tissue one can see through), such as the web of a frog's foot or the wing of a bat. What happens may be noted with a powerful microscope. Watching closely, one may see the white cells beginning to accumulate on the wall of the vessel, just opposite where the germs have entered. The cells move more and more slowly, creeping carefully along, as one often sees a dog tracking his master or game of some sort. By and by the moving mass of cells comes to a stop. Then each cell begins to push out a tiny thread of its own tissue, thrusting it through the wall of the vessel. Little by little the farther end of the delicate filament which has been pushed through the wall grows larger and larger, while the portion within the wall gets smaller. After a little time each cell is found outside the vessel, yet the vessel wall remains as perfect as before. Apparently each cell has made a minute opening and has then tucked itself through, as one might tuck a pocket handkerchief through a ring.

Once outside the blood vessel, the body defenders, moving here and there, quickly discover the germs and proceed at once to devour them. This they do by enclosing them or surrounding them with their own little bodies. If the germs are few, they may soon be destroyed in this way, for the white cells not only swallow germs but digest them. If the number is very great, however, the cells sacrifice themselves in the effort to destroy the germs, taking in more than they are able to digest and destroy. When this occurs, the germs continue to increase, more white cells make their way out of the blood vessels, and a fierce and often long-continued battle is waged between the body defenders and the invading germs. The white cells hasten to the scene of the conflict, from all parts of the body, until the number may be so great as to cause a swelling of the part where the battle is in progress. It is in this way that a boil or an abscess is formed, and the "pus" which is discharged consists of the dead white cells which have laid down their lives in defense of the body. The number of cells which may be sacrificed in such a battle, when it is waged day by day, may be shown in the fact that a single ounce of pus may contain as



THE BATTLE BETWEEN THE WHITE CELLS AND INVADING GERMS.

many as 150,000,000 of these fighting cells which have died in their efforts to repel the invading germs.

When any part of the body is injured, white cells accumulate in great numbers. They spread themselves over the surface of the wounded parts and dexterously weave a new fabric to cement the ends of a broken bone or to cover a surface which has been made bare. In the formation of a portion of the surface from which the skin has been removed, we see the creating, healing process which by means of the blood is being continually carried on in the body.

If you would like to see this illustrated, watch the healing of a cut. The blood forms a clot in the opening, and if you examine that clot through a microscope, you will find a perfect network of little strings or fibers, like the wire used in the building of a bridge, running from one side of the cut to the other. Soon you will see creeping out on those threads some white blood cells, which begin the work of repair. They build up the blood vessels and nerves and fill up the space with new tissue to heal the cut.

Some of the white cells, called phagocytes, act as scavengers, going through the body and gathering up materials that are no longer of any use and conveying them to places where they may be got rid of. There are various sorts of white cells, each of which probably has its own special work to do; but this is a question concerning which very little is known. Do you not see how really wonderful this body of ours is?

The fluid portion of the blood in which the cells float is called plasma. This is composed chiefly of water in which the digested food elements are dissolved. It contains also gases and other poisonous products discharged into it by the tissues. It is necessary for the activity of the blood cells and the tissues that the blood should be in an alkaline condition. The degree of alkalinity of the blood changes considerably. The absorption of waste substances from the tissues and of the acids formed by fermentations from the stomach and intestines lessens this alkalinity. It is also lessened by sedentary habits; by neglect to take proper exercise; by impure air; by the use of alcohol; and by various diseases, especially rheumatism. Certain articles of food, especially meat, which contains uric acid, may lessen the alkalinity of the blood. This is a matter of great importance, for the reason that the blood serum, like the white cells, when in a state of health has the power to destroy germs. But when its alkalinity is lessened by the causes mentioned, this power is to a large extent lost. As a result, the power of the body to defend itself against intruding germs is actually destroyed. This is one of the reasons why persons suffering from indigestion are more liable to contract typhoid fever, cholera, and other germ diseases than are those who have sound stomachs.

We have seen that the blood is the carrier for the body, and therefore it must be kept in constant motion. It used to be thought that the blood simply moved

back and forth in the blood vessels, as the waters of the sea ebb and flow. But in 1621 it was discovered by an English physician, named William Harvey, that the blood circulates, flowing in the blood vessels like a stream, always in one direction, and returning to its source, or starting place.

The heart and the blood vessels.

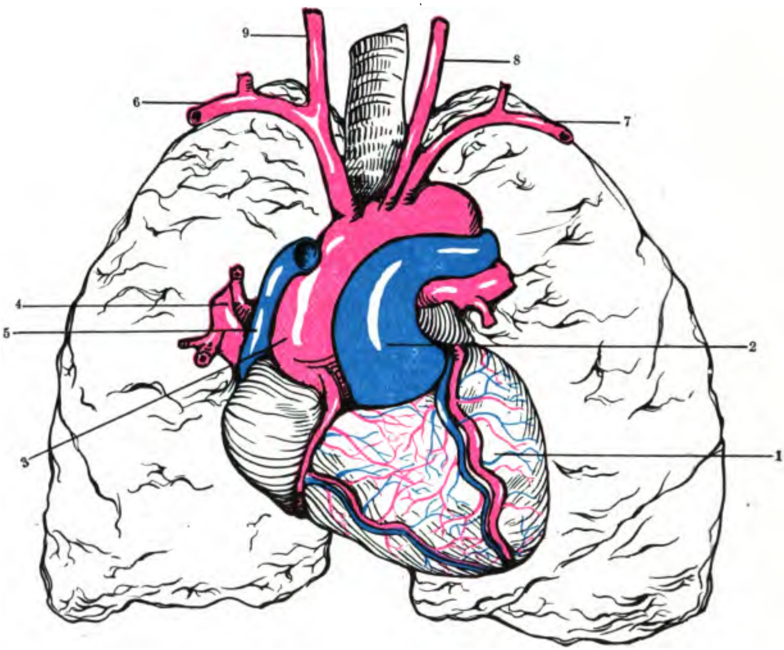
It has been shown by experiments upon animals that all the blood in the body passes through the various organs hundreds of times in the course of a single day. By what wonderful machinery is this rapid and constant circulation of the blood accomplished?

The chief power which causes the circulation of the blood is the beat of the heart. Some organs of the body perform several different kinds of work; but the heart has a single purpose, — that of keeping the living stream of life always flowing through the body, bathing every cell and tissue, feeding every organ, washing away waste particles, and carrying them to the outlets of the body, so that they may be got rid of.

The heart is a hollow muscle about the size of the fist, situated just behind and to the left of the upper and middle portion of the breast bone. Its shape is conical. As it contracts, its *apex* taps the chest wall at a point just below the fifth rib, where its movements can be felt easily.

The heart is double; or, rather, there are two hearts, a right heart and a left heart, almost identical in form. There are valves in the heart, very similar to

those in a pump, so arranged that when the heart contracts, emptying itself, the blood forced out can not return. A very ingenious check-valve arrangement



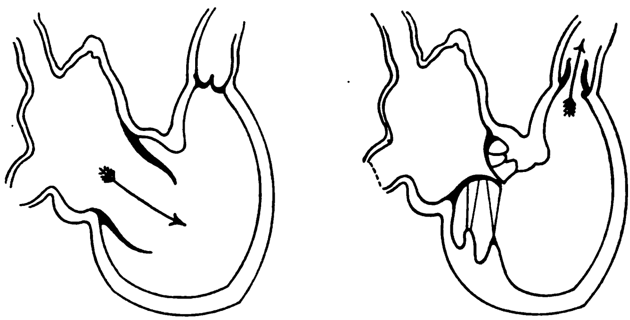
THE HEART.

The Heart with its arteries and veins. 1. heart; 2. pulmonary artery; 3. aorta; 4. pulmonary vein; 5. vena cava superior; 6. right subclavian artery; 7. left subclavian artery; 8. and 9. carotid arteries.

relieves the heart of the pressure of the blood which has been forced out of it, as you can see in the illustration.

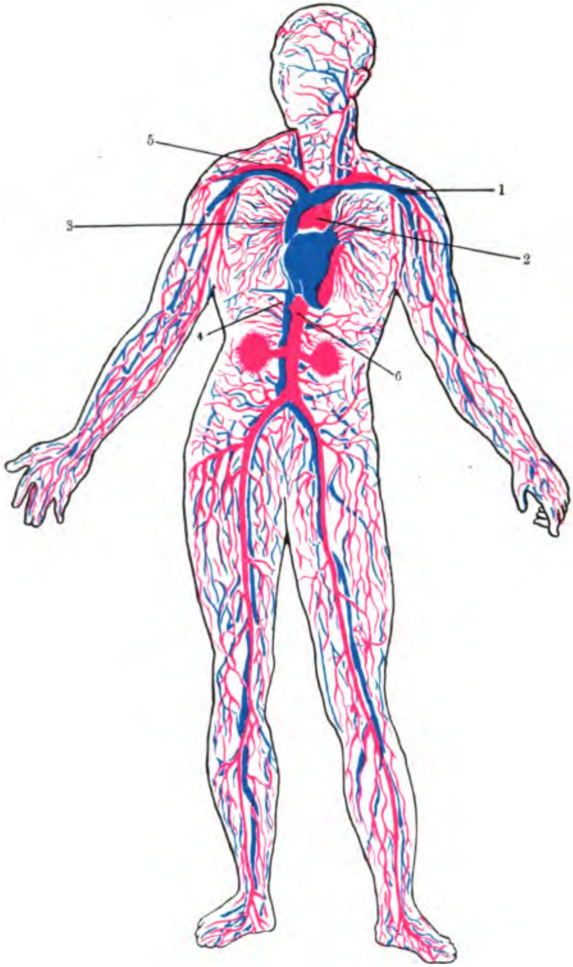
By placing the ear at a point below the fifth rib,

about two inches to the left of the breast bone, where the heart movements are felt, one may hear two distinct sounds made every time the heart beats, which closely resemble the syllables, "lub-dup." These sounds are produced by the movement of the heart and the closure of its valves, and are like the thumping and clicking sounds which accompany the action of a water pump.



CHECK VALVES IN THE HEART.

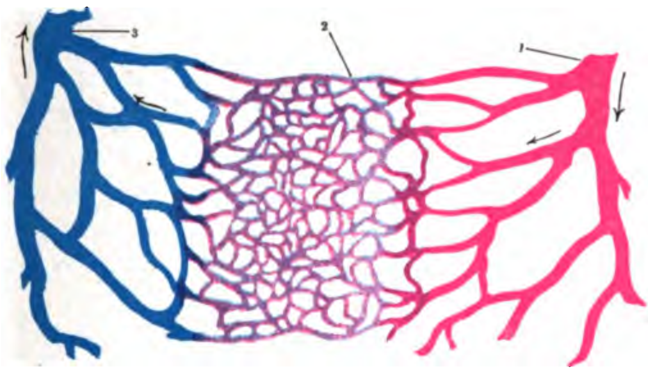
The organs used in the circulation of the blood are not confined to the chest, but they extend throughout the whole body. They consist of the central part, the heart, and two sets of branching tubes connected with it. One of these sets of tubes starts at the right heart, the other at the left heart. The system which begins at the left heart extends throughout the body, ending at the right heart; the one which begins at the right heart is distributed to the lungs only and ends at the left heart, as shown in the picture.



CIRCULATION OF THE BLOOD.

1. aorta; 2. subclavian vein; 3. descending vena cava; 4. ascending vena cava; 5. subclavian artery; 6. descending aorta.

In each set of tubes there is a main tube starting out from the heart, dividing into many branches, which, after becoming very small, combine to form larger ones, finally making large trunks, which again join the heart. The tubes leading out from the heart are called arteries; those which lead back to the heart are called veins. The minute vessels which join the arteries and the veins are called capillaries.



THE PASSAGE OF THE BLOOD FROM ARTERY TO VEIN.
1, artery; 2, capillaries; 3. vein.

The walls of the arteries, and to some extent also the walls of the veins, are muscular and hence are able to contract. The walls of the arteries and veins are thick and strong; the walls of the capillaries, however, are extremely thin, far more delicate than the finest gossamer silk. They are transparent, so that by placing under a microscope a bit of thin tissue,

like the web of the foot of a living frog, one may easily see the blood moving through these minute vessels and study their rhythmical contractions. The contractions of the heart may also be studied, either by placing under a microscope some minute living creature, as a very young minnow, or some still smaller animal form, such as the minute animalculæ which are often seen swimming around in stagnant water. By means of the X-rays it is also possible to study the movements of the human heart.

The three systems of circulation.

(1) The left heart works to supply the body with blood for the building up of its tissues. The right heart works for the purpose of pumping to the lungs for purification the blood which has gathered up the poisonous wastes from the tissues. The blood that goes from the left side of the heart through the arteries is returned through the veins to the right side. It is then pumped to the lungs by the right heart, and, after purification, it is returned from the lungs to the left heart.

The blood thus passes through two circuits: the larger of which, starting with the left side of the heart and ending with the right side, is termed the systemic circulation; the smaller, starting out from the right heart and ending with the left heart, is called the pulmonary, or lesser, circulation.

Each heart is divided into two compartments, one which receives the blood and one which sends it out. The receiving compartment is called the auricle, from

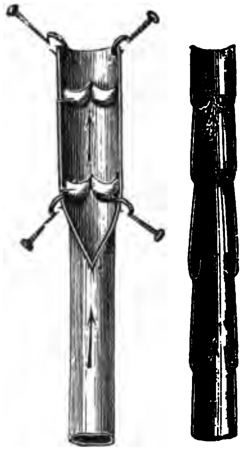
its fancied resemblance to an ear; the compartment which forces out the blood is called the ventricle.

A volume of blood equal to the total amount contained in the body passes through each side of the heart about once every minute. Some portions of the blood, however, complete the circuit in about half this time. The blood travels in the arteries very rapidly, but in the capillaries the blood movements are so slow as to be almost unnoticeable. The length of the capillaries, however, is so very short that the time occupied in passing through them is brief. It has been calculated that the capillaries can hold several times as much blood as the arteries. This partly accounts for the slow movement of the blood in the capillaries.

The network of capillaries in the skin is spread out over an area of more than ten thousand square feet. Those of the rest of the body must be sufficient to cover many times this surface.

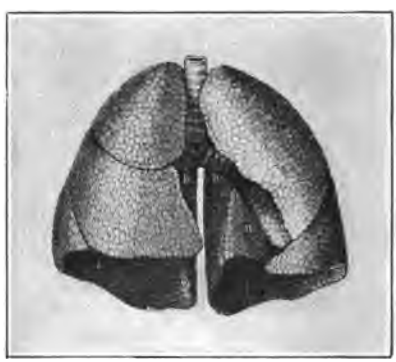
The blood travels much more slowly in the veins than in the arteries. Its force is also very much less, a condition which accounts for the fact that when an artery is cut the blood spurts out with considerable force and in jets corresponding with the beats of the heart; whereas the flow of blood from a cut vein is in a steady stream with very little force. The veins differ from the arteries in that they are supplied at various points with check valves, which prevent a backward movement of the blood, as shown in the illustration.

(2) The pulmonary or lung circulation starts, as we have found, from the right heart and pumps it into the lungs for purification. In the lungs, the blood is spread out in a fine capillary network, distributed in the membrane lining the air passages and air cells, which extend over an area which has been calculated to be about two thousand square feet. After passing through the lungs, the blood is returned to the left heart to be sent throughout the body again. So it goes on hour after hour, day after day, and year after year, as long as one lives.



CHECK VALVES IN THE VEINS.

(3) The portal circulation is a remarkably interesting arrangement of blood vessels connected with the digestive organs and the liver. The blood which is supplied to the stomach and intestines and other organs connected with the work of digestion, on entering the veins does not return at once to the right heart as does the blood from other parts of the body, but is carried to



THE LUNGS.

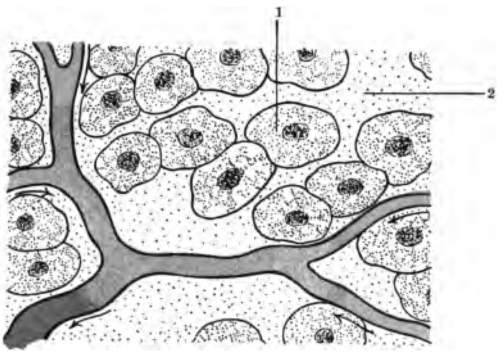
the liver, in which it is again distributed through a set of capillaries so that it may be brought in contact with the living cells of the liver. The liver cells are thus afforded an opportunity to remove impurities that may have been absorbed during the process of digestion and also to act upon the several elements of the food. In this manner it stores up the sugar from the digested starch in the form of glycogen and produces some needed changes in the digested protein.

LYMPHATIC GLAND.

The thin walls of the capillaries permit the escape of a considerable quantity of the blood into the tissues. In other words, there is a constant leakage from the blood vessels. This escaped blood is called lymph.

The lymph is the means of communication, or "middleman," as it has been called, between the cells and the blood. All the cells of the body are bathed in lymph. They live in lymph just as a fish lives in water or as the body as a whole lives in the air. They take up from the lymph the nourishing substances which escape into it from the blood, and discharge into it their waste substances.

The pressure within the blood vessels prevents a return of the lymph into the circulation. Consequently, particular provision is made for the gathering up of these escaped blood elements in a special set of vessels called the lymphatic system. There are located along the vessels at certain points small bodies called lymphatic glands. The vessels do not pass through these glands, but empty themselves into the glands which are drained by vessels on the opposite side. The lymph is therefore passed along from one to another of a series of glands, until it finally reaches a point in the center of the body near the heart, where the various lymphatic vessels converge and discharge their contents into large veins.



THE LYMPH IS THE "MIDDLEMAN" BETWEEN THE CELLS AND THE BLOOD.
1, white corpuscle; 2, lymph.

The battle in the lymph glands.

Germs which enter the body through the skin and find their way into the lymphatics can not reach the deeper and vital parts of the body without running a gantlet of many lymphatic glands, which act as filters, detaining the germs and giving the white cells of the blood, which

are always present in these parts in great numbers, an opportunity to destroy them. The lymphatic glands are placed in great numbers in those parts of the body where germs are likely to enter. It is for this reason that they are so numerous about the neck.

Having studied the several routes by which the blood travels in the body, we may next notice how it is made to travel along these channels. The impulse is given to the blood movement by the heart, which contracts with sufficient force to elevate the blood to a height of several feet in a tube connected with a main artery. Perhaps you can appreciate that the total amount of work done by the heart in twenty-four hours in its contractions, in an average man, is equivalent to lifting one hundred and twenty-four tons one foot high, or lifting a hundredweight one foot high 2480 times, or at the rate of four times a minute for ten hours.

How the blood is circulated.

Even the expenditure of this amount of energy is not sufficient to maintain the movement of the blood current. Other forces are brought into operation which greatly assist this important work. The circulation is aided by the rhythmical contractions of the small arteries and capillaries, which force the blood onward in a steady stream into the veins. The movements of the body produced by contractions of the large muscles of the limbs and trunk aid the circulation by compressing the veins and

thus forcing the blood forward; a return flow is prevented by the valves of the veins. The breathing movements, as we shall see later, produce a sort of suction action in the chest which draws the blood toward the heart.

The beating of the pulse goes steadily on from birth to death without any interruption. How is this possible, since the heart is a muscle and the muscles require rest? An explanation is to be found in the fact that the heart takes a short rest at the end of every beat. A careful study of its action shows that it spends nearly half its time resting.

The rate at which the heart works varies with many conditions. On counting the pulse at the wrist, the ordinary rate in an adult sitting upright is found to be 68. In the same person lying down the pulse rate will be found to be 64 beats, and in the person standing the rate will be increased to 78. Why this change? Walking at a moderate rate usually raises the pulse to about 100, and by running and other violent exercise, it may be increased to 180 or even more. Why? The pulse rate of an infant is 130 to 140; that of a child of ten years, 90. In aged persons the pulse rate is found to be from five to ten beats faster than in middle age. In fever the pulse rate is increased one fourth or more and is sometimes even doubled.

The blood supply of the body in general is regulated by the heart; but each particular part also requires

some regulation of the quantity of blood supplied to it. This is effected by means of nerves similar to those which control the action of the heart. Through the influence of these nerves, the muscular walls of the blood vessels are made to contract or dilate as may be necessary. If more blood is required, the vessels dilate, thus widening the channel and increasing the supply.

How the blood supply is controlled.

If less blood is needed, the vessels contract, thus diminishing the size of the channel through which the blood must flow. These nerves are brought into action when cold, heat, friction, or other irritants are applied to the skin.

Cold causes contraction of the vessel walls; and heat, friction, or other irritants dilate them. The contraction from the effect of the cold, however, is quickly followed by a dilatation, or so-called reaction. The dilatation produced by cold differs from that caused by heat, in that it is more permanent and is accompanied by an active movement of the arteries, whereby the increased amount of blood is pumped through the dilated vessels. Heat apparently dilates the veins more than the arteries and does not increase the activity of the blood current through the skin. It is for this reason that heat gives to the skin a dusky red hue, while the reaction produced by a short application of cold produces a crimson red color. Prolonged cold produces a bluish color, by so contracting the small vessels that the movement of the

blood through the skin is almost entirely prevented. The little blood that remains in the veins becomes so thoroughly charged with carbonic acid gas that it acquires a deep blue color, which gives the blue color to the skin.

Health Problems

1. For purposes of experiment tie a string tightly around your finger and leave it there for a few minutes. Describe what happens to the extremity of the finger. Suppose the string should be left there permanently; what would happen to the finger?

2. If you think it is appropriate to give them this term, show why it is proper to speak of the white blood cells as the "Army of the Interior."

3. Mention some of the common enemies of the body that would destroy it, if the white blood cells were not always on guard and in good fighting condition.

4. Have you ever been in a condition in which germ enemies got the better of you for a time? Can you explain this?

5. Think of some sort of experiment by which you can show that a large proportion of the body is water.

6. What is the meaning of sedentary? Mention sedentary habits of people whom you know. What do such people need to do in order to keep in good health?

7. Physicians tell us to-day that we must be careful not to eat too much meat. Why do they give us this advice?

8. Mention some things that are alkaline. How can you tell whether a thing is alkaline or not?

9. Locate your heart precisely. Point out exactly where it "taps the ribs."

10. Suppose the valves of the right heart should become

weakened, what would happen to the body? Suppose the valves in the left heart should become weakened, what would happen?

11. Can you illustrate the arteries, veins, and capillaries in your body by comparison with the streets of your city? Are there any that you might call arteries, others capillaries, and others veins? Why? Can you speak of arteries, capillaries, and veins in a plant or a tree? Why?

12. Why are the capillaries so fine? Why should not they be as large as veins?

13. Does the heart work harder in a man seven feet tall than one four feet tall? Explain.

14. Why does the heart work faster when one is climbing stairs or running than when he is standing still or sitting down?

15. Show the checks in your own veins. Which way should you have to push the blood in order to show these veins? Why?

16. When one's feet are cold or when he has a headache, why does he take a hot foot bath? Why does he put on cold water after he has had a hot bath?

17. Write a story entitled: "The Traveling Exchange" and show all the good which can be performed by the blood.

Review Questions

1. What is it that maintains the life of the tissues of the body?

2. Are the cells that compose any organ constantly changing? How do we know?

3. What is the carrier of the body? What does it carry, and where does it carry it?

4. What should you see in the blood if you should examine it under a microscope?

5. What is the meaning of corpuscle?

6. How many blood cells in a drop of blood?

7. If all the blood cells in the body were put together in a row how long a line would they make?

8. How rapidly are blood cells made in the body?

9. How do the red blood cells look under a microscope? What is their office?

10. How do the white blood cells look under the microscope? What is another name for the white blood cells? What is their office?

11. Suppose there are not enough white blood cells in the body when it is attacked by germs, what may happen?

12. How is a boil, an abscess, or pus formed?

13. How does the blood heal wounds?

14. Describe the work of the plasma.

15. What is the meaning of the circulation of the blood and the cause of it?

16. How many times does the blood in the body pass through the different organs?

17. Describe the heart, telling about its shape, its parts, and its work.

18. What is the meaning of the blood vessels?

19. What are the differences among an artery, a vein, and a capillary?

20. What is the systemic circulation? The pulmonary?

21. Why does the blood travel more slowly in the veins than in the arteries?

22. How has Nature arranged it so that the blood in the veins cannot flow back into the arteries?

23. Why is all the blood sent to the lungs?

24. Why is some of the blood sent to the liver?

25. What is the lymphatic circulation?

26. What are the lymphatic glands? What is their use in the body? What is the necessity for these glands?

27. What helps the heart to circulate the blood?

28. How frequently does the pulse beat in an average adult (*a*) when he is sitting upright, (*b*) when he is standing, (*c*) when he is walking, (*d*) when he is running rapidly?

29. How is the blood supply to any organ controlled so that it will get just the amount it needs?

30. What is the effect of cold upon the circulation in any of the blood vessels? Of heat upon the circulation? Why does cold produce a bluish color in the skin, and heat, a dusky red hue?

CHAPTER VI

Pure Blood and a Sound Heart

The importance of blood purity.

The life of the body depends, as we have seen, upon the blood. The condition of the blood is therefore a matter of the greatest importance. Upon its purity depend not only the nutrition of the body but the power of the body to resist diseases of all kinds. Impure blood is the cause of a large proportion of the diseases from which human beings suffer.

The prompt healing of a cut or wound is evidence of clean, pure blood. When the skin is broken, germs are admitted to the tissues, from which they are ordinarily kept out by the skin. If the tissues are kept in a healthy state by pure and vigorous blood, the few germs that enter are quickly destroyed, and there is no pus; but when the blood is not pure, the cells and the blood serum are not able to make the active defense necessary. So the germs multiply, suppuration (making of pus) occurs, and the wound may take a long time to heal. It is thus clear that one's blood cells should be kept in good fighting condition, so they may have the power to resist and destroy germs. We owe

our protection or recovery from infectious diseases of all sorts chiefly to the activity of these wonderful little fighters.

It has been said that "all life is under water." The cells of the body are bathed in the lymph which drains out from the blood vessels. If the blood is impure, every cell and fiber of the body is bathed by an impure fluid, and must be more or less injured.

Picture in your mind a glass globe filled with water, with fishes swimming about in it. Imagine that indigo, ink, or some other kind of coloring matter is dropped into the water. All the water will at once become tinged, and, if the coloring matter is poisonous, the fishes will soon show signs of uneasiness; and unless they are relieved by the water's being changed, they will soon die. This illustrates the condition of the living cells of the body bathed in impure blood. Every one is injured by the impurities brought in contact with it.

You see now why, as you have already learned, all substances containing poisons, such as alcoholic drinks, and drugs such as opium and tobacco, injure the blood and lessen its defensive power. When alcohol is taken freely, the blood loses in part its power to carry oxygen. This accounts for the bluish appearance of the face, nose, and lips of an "alcoholic," or one who drinks a good deal of whisky, beer, or the like. Irritating substances such as pepper and mustard are also injurious to the blood.

Eating too much will render the blood impure by filling it with unused materials, which must be treated as waste matter.

Overwork and lack of sleep render the blood impure because the body is then not able to get rid of the waste tissues or poisons which form in large quantities when the body is at work. The work of repair in the body is more active during sleep than during waking time. The red cells of the blood which are worn out are replaced, and thus the red color of the blood is maintained. If one does not sleep, this repair of the blood does not take place so perfectly.

Neglect to maintain the right activity of the organs that get rid of wastes — the lungs, the kidneys, and the bowels — allows these waste matters to accumulate in the blood, and they spoil it. If the lungs are not rendered active by proper exercise, the blood will not get a sufficient amount of oxygen to burn up the wastes, and they will get into the skin and other tissues, and will produce a dull, muddy complexion and other signs of impurity of the blood.

When the bowels do not act regularly — become constipated — the poisonous matters which are retained are absorbed into the blood, and they may become a source of disturbance and injury throughout the body. If a sufficient amount of water is not taken to dilute the blood, wash the tissues, and assist the kidneys in removing the acid poisons which it is their particular duty to separate from the blood, these in-

jurious substances are retained and give rise to headache, rheumatism, gout, and other maladies.

The idea that the blood may be purified by medicine of any sort is a great error, which has been the cause of much mischief. There are no herbs nor drugs, the taking of which will purify the blood. The blood is not purified by putting something into it but by taking something out of it. Water is the universal cleansing agent, and its free use is necessary for blood purification. It washes the tissues, dilutes the blood, and encourages the kidneys to remove wastes. To undertake to purify the blood by means of pills is about as reasonable as to undertake to cleanse a soiled garment by the same means.

How to purify the blood.

Vigorous exercise out of doors is one of the most important means of maintaining blood purity. Why?

An insufficient amount of food very soon makes the blood poor and thin. Of course, the blood must be enriched by an ample supply of pure foods, as well as kept pure by the removal of wastes and the keeping out of unwholesome materials.

Cold baths increase the number of active cells in the blood. Why, do you think? This has been proved by actually counting the number of cells before and after a bath. It must not be supposed that the cells added to the blood are formed in this short time. Cells which have been held idle are by this means brought into the active circulation and made useful.

If, however, the cold bath is taken regularly from day to day, there is an actual increase in the number of blood cells formed. In this way, the cold bath increases the resisting power of the body and rallies the blood cells, so to speak, calling them out from their hiding places and preparing them to fight with vigor the battles that must be waged every moment in defense of the body. Cold baths also improve the quality of the blood by increasing its alkalinity. The circulation of the blood is quickened and improved by the cold bath. It increases the force of the heart beat, and deepens the breathing, so that an increased amount of oxygen is taken into the lungs for the purification of the blood. But it should be remembered that one must always react to cold baths or they may injure him. That is, he must feel warm and vigorous after them. Most people cannot remain in cold water for a long period; they may become chilled and seriously injured if they try it.

Things that affect the heart unfavorably.

In order that the blood may perform its work, it is necessary not only that it should be rich in food elements and free from impure substances, but it must also be circulated properly by a strong heart.

Nature has provided for suiting the action of the heart to all the ordinary needs of life; and if we are careful not to impose needless burdens upon it, nor to illtreat it in any way, we may expect it to do its work well for a long lifetime. If it fails to do this,

the cause is usually some fault for which we are ourselves responsible.

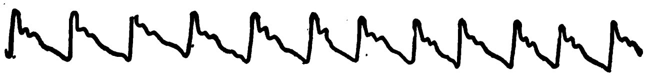
Great extremes of heat and cold are injurious to the heart. Heat stimulates it to a high degree, while the effect of cold is to depress and weaken it and also the small blood vessels. Hence, you see it is of importance to protect the body by adapting the clothing to the seasons and the needs of daily life. It is especially important to clothe the feet well, so that a proper balance of the circulation may be maintained. Many of the large veins, especially in the extremities, are located near the surface, and hard pressure interferes with the flow of blood through them. For this reason, elastics on the arms or legs, and tight belts or collars are injurious.

Very strong emotions affect the heart injuriously. Violent anger has sometimes caused a person to drop dead from sudden heart failure. Even joyful tidings have sometimes caused death. Why? The lesson to be learned from these facts is that we should keep the emotions and passions well under control. Does this mean we should not be joyful? What does it mean?

The pulse of the tobacco user indicates unmistakably the injury which smoking does to the heart. It has lost its firm, steady beat and is feeble and irregular. This condition is so well known that it has received the name of "tobacco heart." The tobacco heart has become very common among young men as the result

of cigarette smoking. A large proportion of those who volunteer for military service are rejected because they have been found to have "tobacco heart."

Alcohol injures the muscles of the heart and the blood vessels, and if its use is kept up it may result in, a hardening of the walls of the arteries, which will bring on old age too soon. The habitual use of alcohol causes the heart to be overloaded with fat, which interferes with its work. In other cases, its muscular



Pulse beat of healthy person.

Pulse beat of tobacco user.

Pulse beat of drunkard.

HOW TOBACCO AND ALCOHOL AFFECT THE HEART.

tissue is changed to fat and it loses its strength, so that the heart beat is a mere flutter. The muscular walls of the small arteries of the brain and other parts are likely to undergo a similar change, and they may become so weak that they are not able to resist the pressure of the blood. Apoplexy (the bursting of a blood vessel in the brain) is more frequent among those who use alcohol than among abstainers.

Alcohol quickens the pulse, not by strengthening the heart, but by paralyzing the nerve centers that control

the heart and the small blood vessels. In consequence, the heart "runs away" as it were, like a steam engine which has lost its "governor" or a clock pendulum from which the weight has been removed. The red face and eyes so often seen in a drunkard are due to a paralysis of the small blood vessels so that they are always full of blood.

All these things show us that alcohol has a very bad effect upon the heart. Can one afford to take the risk of in any way weakening this wonderful organ? In a severe illness, everything depends upon the ability of the heart to stand the strain of the disease, and if it has been weakened by any cause, it may suddenly fail. It has been found that heavy beer drinkers succumb very readily to disease, on account of the weakened condition of the heart, known as "beer drinker's heart." Should you expect this? Why?

Many of the headache remedies commonly used are manufactured from coal tar, and these have a very injurious effect upon the heart. Should medicine of any kind ever be taken except by the advice of a physician? Why?

Severe exercise may injure the heart by placing too great a strain on it. Going to excess in football, bicycle riding, and other severe and long-continued exercise may overwork the heart and cause incurable disease. The heart, like any other muscle, enlarges by exercise. An enlarged condition of the heart known as "athletic heart" may be caused by too severe

exercise. In this condition there is frequently trouble with the valves of the heart, which do not close completely, but allow a leakage of the blood backward in the circulation. This increases the work of the heart, as some of the blood must be pumped twice.

The heart is developed and made strong by exercise,

TENNIS IS A GOOD GAME, BUT IF PLAYED TOO VIOLENTLY THE HEART WILL BE INJURED.

How to strengthen the heart.

just as is any other muscle. The size of the heart is, as a rule, proportioned to the amount of work it has had to perform. Animals kept in cages or in captivity have been found upon examination after death to have much smaller hearts than those of other animals of the same species. The heart of a race horse is much larger than that of an ordinary

work horse. The heart of a stag, a very active animal, is, in proportion to the size of the animal, about twice as large as that of a pen-fed pig. Can you tell why?

One who has a well-developed and strong heart has more vigor, more endurance, and more courage than

VIGOROUS WALKING STRENGTHENS THE HEART.

he otherwise would have. When one not accustomed to daily active exercise hurries to catch a train or runs up a flight of stairs, he gets out of breath very easily and perhaps suffers from a heavy beating or palpitation of the heart. Enough daily vigorous exercise should be taken to keep the heart strong and vig-

orous, so that it will not be affected by moderate exertion.

The same exercise which strengthens the legs in running, or the arms in rowing, also strengthens the heart by forcing it to do the work necessary to pump the blood to the active muscles, and carry it to the lungs for purification.

One not accustomed to exercise should begin with a little at a time, increasing the amount as the heart becomes stronger. Why? The pulse beat and the breath will show how much exercise it is safe to take. Take a short run of about a minute or a trot of a few minutes and notice the effect upon your breathing and your pulse. One should avoid getting very much out of breath and exciting the heart to such a degree as to produce a very rapid pulse. Why? The shortness of breath occasioned by exercise should pass away on resting a few minutes, and the pulse also should return to its ordinary rate. Outdoor games — swimming, rowing, walking, and especially mountain climbing — are excellent forms of exercise for strengthening the heart.

Health Problems

1. Can you tell when you look at a person whether or not his blood is pure? Mention all the signs that indicate impurity.

2. Can you tell when a person has not had sleep enough? Describe all the signs of lack of sleep.

3. Have you ever noticed the eyes and skin of a drunkard? If so, do they seem like the eyes and skin of other people? Why does the end of a drunkard's nose seem so red?

4. Can a person who works at a desk all day and who does not take exercise in the open air keep his blood from becoming impure? Explain.

5. Should you expect to find pure blood in people who were living all the time in a town or city where the sun could not shine because of the smoke and dust? Explain.

6. A good many people think they have to take blood purifiers in the spring. Why should they feel the need of such things especially in the spring? Do you think they can get their blood purified by taking such medicines?

7. Do you take cold baths? If so, describe all your experiences from the moment the first drop touches you until you are through with the bath.

8. Do you think it would be wise for a weak person who is not accustomed to cold baths to jump into a tub of very cold water or into a cold river or a cold lake?

9. I have known boys who wore very tight belts to hold up their trousers. Do you think they are likely to be injured in this way? Why?

10. Why will no boy or man who uses tobacco or alcohol be allowed to go on an athletic team in the high schools or colleges?

11. Have you known people who would get out of breath if they even walked rapidly? What is probably the matter with such people? How long can you run without getting out of breath?

12. Does one need to take special heart exercises or will the heart take care of itself if one lives right, — that is, if he takes enough food for his needs, exercises regularly so as to keep his body and muscles in good condition, keeps from putting poisons into his body, and so on?

Review Questions

1. Upon what does the life of the body depend?
2. Why should blood cells be kept in good fighting condition?

3. Suppose the blood is impure; what happens to every cell in the body?

4. How do alcoholic drinks, such as whisky and beer, affect the blood? How can you tell a person who habitually drinks wine and whisky in large quantities?

5. What is the effect of such things as pepper and mustard on the body?

6. How does eating affect the blood? How does sleep?

7. What will happen to the blood if the wastes are not got rid of?

8. What organs have to do mainly with getting rid of wastes?

9. Why is water valuable in keeping the blood pure?

10. Can one make the blood pure by taking pills? Why? What is the only way in which one can make his blood pure?

11. Mention all the benefits that come from cold baths if one can take them.

12. Why is it necessary to have a strong heart?

13. If one does not illtreat his heart, how long will it serve him?

14. Tell how these things affect the heart: clothing; strong emotions, as anger or the like; tobacco; alcohol; very severe exercise.

15. Why do people who use a good deal of tobacco and alcohol seem less able to resist diseases than others?

16. Should one use headache remedies without consulting a physician?

17. How can one strengthen his heart so that it will be ready for any need of daily life?

CHAPTER VII

The Breath of Life

From what you have already learned you know that we breathe to obtain the life-giving gas called oxygen and to expel the poisonous gas called carbon dioxide which is formed in all living things. Every one of the many millions of minute living creatures or cells of which the body is made up must breathe in order to live. That is, it must get a constant supply of oxygen and must get rid of its carbon dioxide. Oxygen is absolutely essential to life. Its great use in the body is to set free or bring into action the energy stored in the body in the form of digested and assimilated food. We have found that the body gets its warmth and power to work from the burning or oxidation of these food substances in the cell. We know that the burning of wood or coal in a stove can not take place without oxygen. If a stove is made air tight by shutting up all the draughts, the fire will burn low and after a while go out altogether. Oxygen is just as necessary for the burning of food, the fuel of the body.

Oxygen, the life-giving gas.

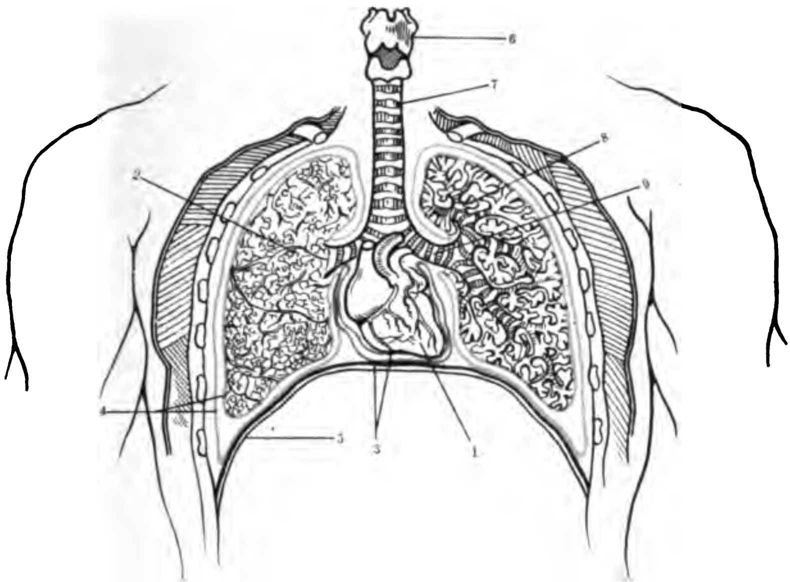
The cells, packed as they are in the interior of the body, cannot get their oxygen directly from the air, as the amœba can from the water. It must therefore be taken into the body and carried to them. In the division of labor among the cells, the work of taking into the body the supply of oxygen needed by the cells and expelling the carbon dioxide formed by them is given to the lungs. Just as the digestive organs prepare the food for all the cells, so the lungs supply the oxygen for all the cells. The digestive organs get their oxygen from the lungs, the lungs get their food supply from the digestive organs, and so also every body cell by its work helps every other cell.

There must, of course, be some means of communication between the lungs and the cells, by which the oxygen from the lungs may reach the cells, and the carbon dioxide from the cells may reach the lungs. This is provided for by the circulation of the blood, which is, as we have seen, a carrier between the lungs and the tissues as well as between the digestive organs and the tissues.

The breathing apparatus.

The air is sucked into the lungs by means of a tube called the windpipe or trachea, which at its upper end is widened into a small chamber called the larynx, a box made of cartilage in which the vocal cords are placed, and which communicates with the air through the nose and mouth. At its lower end, the trachea is divided into two branches, called bronchial tubes, one of which passes to the right

and one to the left of the chest. Each of these is divided and subdivided like the branches of a tree into innumerable smaller tubes or bronchi, the very smallest of which are called bronchioles. The bronchi-



THE HEART AND BREATHING APPARATUS.

1, heart; 2, lung; 3, pericardium; 4, pleura; 5, diaphragm; 6, larynx; 7, trachea; 8, bronchioles; 9, bronchial tube.

oles end in small pouches, the sides of which are everywhere pitted with little recesses or tiny sacs called *air cells*. The total number of air cells in the lungs has been estimated to be not less than 1,700,000. The term *cell* is here used in its ordinary sense, meaning a

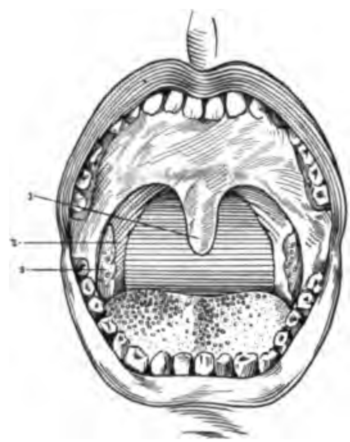
small chamber, and not in the sense in which we used it in previous chapters. What did it mean then?

The air cells and air tubes are bound together by means of tissues in which there are a large number of elastic fibers. These enable the lungs to stretch or expand when they are filled with air. The whole is completely enclosed in a membrane called the pleura.

The great purpose of the lungs is, of course, to bring the blood in contact with the air. The lining membrane of the air cells is of such marvelous thinness that 2500 layers would make but an inch in thickness. On account of the immense number of air cells and minute air tubes, the extent of this membrane is so great that if it were spread out over a flat surface it would cover hundreds of square feet. Immediately under this delicate membrane, in the walls of the air cells, is a very remarkable network of capillaries, which as you already know are minute blood vessels. The blood which passes through this wonderful capillary network is, by reason of the thinness of the lining membrane, exposed to the air in the most thorough manner possible. All the blood in the body passes through the lung capillaries once every minute and a quarter.

The passages which lead to the lungs begin with the mouth and the nostrils. The nostrils lead to the nasal cavity. This cavity is divided for about one half its length by means of a partition called the septum. The sides of the nasal cavity are covered with mucous membrane, the extent of which is greatly increased by scroll-

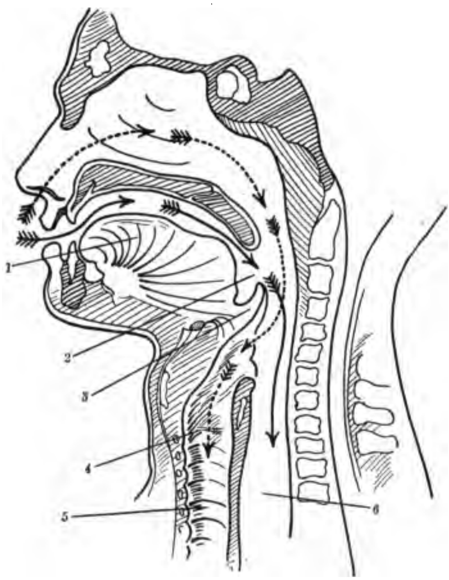
like projections of bone and cartilage from the outer walls of the cavity, as you see in the picture. The nasal cavity and the cavity of the mouth unite at their back parts to form the pharynx, which is separated from the mouth by a hanging partition, — the soft palate. Everything which enters the lungs and the stomach passes through the pharynx. On either side of the pharynx are the tonsils, two remarkable glands which are placed at the entrance to the body to protect it against germs which enter with the air and food.



WHY DID NATURE PLACE THE TONSILS WHERE YOU SEE THEM? 1, rivula; 2, pillars of fauces; 3, tonsils.

When germs are present in such great numbers that the tonsils are not able to destroy them all, some of the germs penetrate the tissues and the tonsils become infected. The germs creep down into little crypts or pockets, of which the tonsils are full. They fill these pockets with germs as a boy may fill his pocket with marbles. Sometimes so many germs cluster upon the tonsils that they become overwhelmed and lose their power to destroy the germs; the result is that the germs destroy the tonsil. The tonsils then become inflamed and enlarged, and quite frequently their removal is necessary. In-

fection from diseased tonsils may be carried to the lymph glands of the neck and to the lungs, and enlarged glands or tuberculosis may result. One of the best means of protecting the tonsils is by breathing plenty of pure, cold, fresh air. Dust-laden air should be avoided.



THE ROUTE WHICH THE AIR AND THE FOOD TAKE ON THE WAY TO THE LUNGS AND THE STOMACH.

1, tongue; 2, pharynx; 3, epiglottis; 4, larynx; 5, trachea; 6, esophagus.

Just beyond the root of the tongue, in the front wall of the pharnyx, is an opening called the glottis, which leads into the larynx, the entrance to the windpipe. The glottis is guarded by a closely fitting covering called the epiglottis, consisting of a leaf-shaped cartilage, one side of which is hinged at the root of the tongue in such a manner that, in the act of swallowing, the cover is tightly closed, preventing the entrance of food or drink into the windpipe. The pharynx itself leads to the esophagus, or food pipe.

The whole of the breathing apparatus is lined with

mucous membrane, which is kept moist with mucus. Particles of dust and germs which are carried down into the air passages are caught by this mucus, much as flies are caught on a sticky fly paper. Except in the air cells and the pharynx, the walls of the air passages may be shown by the microscope to be covered by minute hairs. By the constant movement of these hairs, or cilia as they are called, a stream of mucus is swept upwards towards the mouth, carrying with it the captured dust and germs. In this way the air is cleansed, and dust and germs are in a great measure prevented from reaching the air cells of the lungs.

What takes place in the lungs.

If you could watch the blood as it passes through the lung capillaries, you would see a remarkable change taking place in it. The dark purplish hue which it has when it enters the capillaries is changed for a bright crimson before it leaves them and starts for the heart. What is the reason for this wonderful change of color? It means that there has been an actual change in the quality of the blood. A part of its cargo of carbon dioxide has been discharged, and a fresh load of oxygen taken on board by the red cells. That is, as the blood flows through the capillaries in the lungs, it gives off carbon dioxide into the air sacs and receives in its place a fresh supply of oxygen.

The opposite kind of change you would see taking place in the capillaries of the body. Here the blood

loses its bright crimson color and takes on a darker hue. The oxygen received from the lungs is, when

WHEN THE BREATH GOES OUT.

WHEN THE BREATH GOES IN.

the blood reaches the capillaries anywhere, sent through the thin walls of the vessels into the lymph. The cells take up the oxygen from the lymph in which they live

(just as the one-celled animal takes its oxygen from the water) and discharge into it their carbon dioxide, which is sent from the lymph into the capillaries. Just as in the lung capillaries the blood gives up carbon dioxide and takes on oxygen, so in the capillaries of the other tissues it gives up oxygen and takes on carbon dioxide; and it is this change which causes it to darken in color. For this reason the blood in the arteries, which carry the purified blood *from* the heart, is much brighter in color than that in the veins, which return the impure blood *to* the heart. It is this dark color of the blood that causes the veins that can be seen through the skin to appear blue.

The change that takes place in the blood in the lung capillaries causes a corresponding change in the air in the lungs. The double process of taking oxygen out of it and putting carbon dioxide into it spoils the air and makes it necessary that it should be constantly renewed. A constant change of air in the lungs is essential to life. Why?

How the lungs are ventilated.

Breathing has for its purpose to ventilate the lungs by putting fresh air into them. Do we at each breath expel all the air in the lungs and take in an entire new supply? As a rule only from one tenth to one fifth part of the air in the lungs is changed every time we breathe.

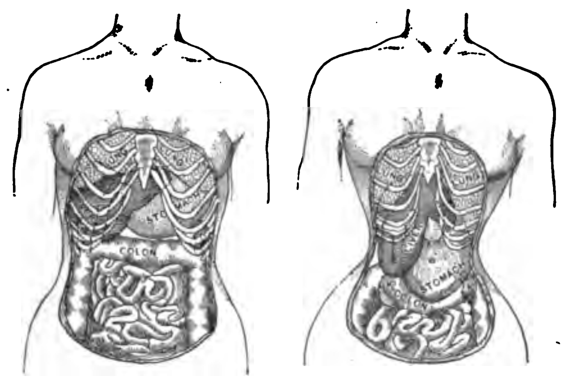
The air is brought into the lungs by a most wonderful pumping device. The lungs are suspended in an air-tight box, — the chest cavity or thorax. The ribs

with the muscles and other tissues that cover them form the sides of the thorax. The backbone and the chest bone also help to form the chest walls. The floor or under side of the cavity is formed by a broad strong muscle called the diaphragm, which separates the thorax from the abdomen.

The diaphragm acts very much like the piston of a pump. It moves up and down, pulling the air into the lungs as it descends.

Air is made to enter the lungs by enlarging the chest cavity or thorax. This is accompanied by a downward movement of the diaphragm and an outward movement in all directions of the side walls of the chest. This widening is done by means of the muscles which lift the ribs and pull them outward. When these muscles cease their pulling, the chest walls return to their former position, and the air which was sucked into the lungs by enlarging the chest is forced out again. The natural elasticity of the lungs and the contraction of the muscles of the abdomen also aid in expelling the air. The lungs act much like a pair of bellows, except that the air passes out and in at the same opening. The windpipe is the nozzle of the bellows, the lungs the body, and the points of the ribs on either side the two handles. When the muscles contract, the points of the ribs are separated, just as the handles of a pair of bellows are drawn apart. This may easily be seen in the panting of a dog, or in the breathing of a long-distance runner.

There are thus two acts in breathing: the first, or drawing in of the breath, is called inspiration; the second, or sending out of the breath, is called expiration. As a rule the lungs act once for every four heart beats. See how long you can hold your breath. It is not ordinarily possible to do this for more than half a minute, but if you take several deep inspirations, you will find you can hold the breath much longer. Why? The very longest time, however, that the breath can be held even by those most practiced in it, such as deep sea divers, is three minutes.



NATURAL FORM. EFFECT OF TIGHT LACING.

How to breathe correctly.

In natural breathing, when the movements are not in any way interfered with, there is a movement of the whole trunk, chiefly in the region of the waist. There are two very harmful modes of breathing which must be avoided. One of these is called costal or "rib" breathing, in which the

movement is chiefly in the upper part of the chest and the diaphragm does scarcely any work. This style of breathing is common among civilized women, for the reason that they constrict the body with corsets and other tight garments and so interfere with the movements of the diaphragm and the lower rib muscles. The work of the diaphragm assists the circulation and the digestion as well as the breathing, and anything that interferes with its action must be injurious.

This style of breathing is so common among civilized women that it has given rise to the idea that they naturally breathe in a different way from men, with the upper part of the chest alone. This idea is shown to be incorrect by the fact that boys and girls and uncivilized men and women breathe in exactly the same manner. An examination of the most primitive Indian tribes in the United States, also careful observations of Chinese, Mexican, Egyptian and Arab women, whose clothing has never been such as to interfere with the natural breathing movements, showed that women naturally breathe in precisely the same way as men, by an expansion of the whole chest, particularly the lower part.

Another unnatural style of breathing is called "abdominal breathing," which is most common among men who lead sedentary lives, in whom the muscles of the abdomen are usually weakened. The weakened muscles yield to the downward pressure of the diaphragm, and the abdomen bulges forward; but there

is very little movement of the rib muscles. The diaphragm does all the work, and the upper thorax does not expand at all. This greatly interferes with the proper ventilation of the lungs.

Neither costal nor abdominal breathing brings the lungs fully into action. In those parts that remain idle, the air stagnates, and carbon dioxide and other poisons accumulate. The germs of pneumonia and tuberculosis and other disease-producing microbes are likely to find lodgment in these idle parts. Should the breathing movements be such as to expand and bring into action all portions of the lungs?

The muscles of the abdomen are of assistance to us in breathing. As the breath is drawn in when the chest is fully expanded, the abdominal muscles are stretched and made tense, because of the pressure of the diaphragm upon the organs contained in the abdomen. In expiration, these muscles contract, as does rubber released after stretching; and by pushing the abdominal organs upward again, they aid in crowding the air out of the lungs, and in preparing for another incoming breath. In order to serve this useful purpose, the abdominal muscles must, of course, be kept vigorous by exercise.

The proper passage for the air to pass into the lungs is through the nostrils, which are especially fitted for purifying and warming it. The nostrils are guarded by hairs for straining out dust, and the mucus also catches dust and germs. The nose not only acts as a

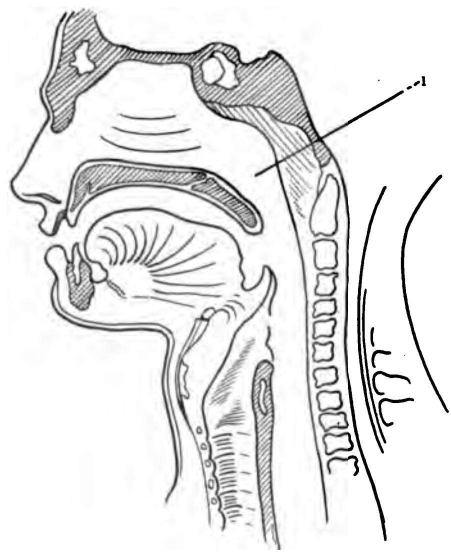
strainer, but it also warms the air, moistens it when too dry, and warns us when it is impure.

Many persons acquire the harmful habit of breathing through the mouth. Mouth breathing in children is usually caused by *adenoids*, a growth of tissue which often nearly fills the breathing passages. You know

BEFORE AND AFTER REMOVAL OF ADENOIDS.

how uncomfortable, how stuffy and stupid you feel when the nasal passages are obstructed by means of a "cold in the head." The boy or girl who has adenoids is always in this condition. As a result of the obstruction of the air passages, the whole body suffers for lack of oxygen. The mouth breather can usually be distinguished by his peculiar expression and half-dazed condition. He is inattentive and cannot understand

or study well. His eyes are usually dull, his expression stupid, and the open mouth, which is necessary for the passage of air, adds to the unattractiveness of his appearance. Sometimes as a result of mouth breathing the features become distorted, the upper lip becomes shortened, and the upper teeth project. Adenoids are frequently a cause of deafness. A physician should always be consulted when mouth breathing is found to be a habit. Removal of the adenoids is a very simple matter, but their effects if allowed to remain are serious and may affect the whole after life.



WHERE ADENOIDS ARE FOUND.

"To breathe well is to live well,—to live longer and better."

While the lungs are to some extent under our control, still their action is, like that of the heart, automatic, or self-regulating. During sleep as well as during waking hours, their movements are carried on with rhythmical regularity. The breathing is not so deep

during sleep as during activity. It is also slower. Less oxygen is used when the body is asleep, and this results in lessened breathing. The work of the liver and the kidneys and the repairing work of the cells goes on during sleep, and this requires oxygen. Hence the body should be supplied with an abundance of fresh air during sleep by proper ventilation of the sleeping rooms. The amount of air taken in during sleep may be increased by enlarging the capacity of the lungs by suitable exercise while one is awake. It has been found by experiment that the amount of air taken into the lungs during sleep was doubled in students whose breathing capacity had been increased by exercise.

How breathing aids the circulation and digestion.

The act of breathing is a blood-pumping process, as well as the means by which air is moved in and out of the lungs. The enlarging of the thorax, by means of which air is sucked into the lungs, also works at the same time to suck the blood up toward the great veins that lead to the heart. At the same moment, the downward pressure of the diaphragm, which presses the abdominal organs against the muscular walls of the abdomen, serves to force the blood upward. This empties the blood of the veins in the abdominal cavity into the chest, thus helping it on toward the heart. You can see then that deep breathing aids the circulation of the blood.

The stomach lies just below the diaphragm, which, as it moves up and down, kneads the stomach and its

contents and so assists the work of mingling the foods and the digestive fluids. In ordinary breathing in a quiet person, the movements of the chest are slight, and the action of the diaphragm produces little effect; but by moderate exercise the movements are more than doubled, and the stomach is then kneaded in a vigorous manner. In this way moderate exercise after eating is beneficial, though violent exercise should be avoided. Why? Would the practice of taking breathing exercises after meals be helpful to digestion? Why?

Effects of alcohol and tobacco on the lungs.

The use of alcohol or tobacco is injurious to the respiratory passages and the lungs, as you might expect. You already know that alcohol greatly weakens the power of the body to resist germs. One who uses alcohol is therefore especially liable to attacks of grip and pneumonia, as well as to catarrh of the air passages. The smoke of cigarettes contains a poisonous gas called carbon monoxide. When this smoke is inhaled, as it frequently is by smokers, both the poisonous gas and the tobacco poison get into the blood in the lung capillaries and are a source of injury to the cells.

Developing lung capacity.

Nothing is of more importance for a long and vigorous life than large lung capacity. By means of an instrument called the spirometer, into which a person breathes after taking a deep inspiration, it is possible to find out the vital capacity, that is, the amount of air change which takes place in the lungs. A person's lung strength can be learned,

however, without the use of the spirometer, by testing the ability to endure exercise which taxes breathing power, such as running up and down stairs or other running exercises. Extreme breathlessness caused by moderate exercise indicates either that the heart is weak or that the breathing capacity needs developing.

ENLARGING THE CHEST.

Any exercise which compels full, deep breathing is a valuable means of developing the lung capacity. Breathing power depends upon the strength of the muscles that control the chest walls, as well as upon the size of the chest. Exercise in a gymnasium, chopping and sawing wood, digging, laundry work, scrubbing, and all sorts of active housework and farm work are excellent means of developing the chest. Should you expect this? Why?

When a chest is not stretched to its fullest capacity many times daily, it is likely to lose its capacity, especially after the age of thirty. The proper time for chest development is in childhood and youth. During this period the soundness of the heart makes it possible to take without injury those vigorous exercises which are necessary to secure the highest degree of lung capacity.

We have seen that the breathing movements are for the purpose of supplying the cells with oxygen, and the breathing is therefore regulated according to the needs of the cells. When the large muscles of the body are actively at work, as in running, oxygen is rapidly used up by the working cells, and the blood is filled with carbon dioxide. The heart beats more rapidly to send the impure blood to the lungs for purification and a supply of oxygen. In this way a sort of thirst for air is created and deep and rapid breathing is the result. Exercises of this sort are far superior to so-called "breathing exercises," in which the lungs are forcibly compelled to take in more than the ordinary amount of air, though these latter exercises have some value. The impulse which comes from within, from the so-called "respiratory centers," stimulates the respiratory muscles so that they cause the chest to execute the strongest breathing movements with the greatest ease, ventilating every portion of the lungs and filling every air cell to the utmost capacity.

Running, or other active exercise of the leg muscles, is an excellent means of increasing the lung capacity. At first the breathing is slightly difficult, but after a short time, when the runner has his "second wind," respiration becomes easier. The entire lung surface is then brought into action. There is an important lesson in this, — namely, that in ordinary breathing the entire lungs are not brought into use and hence are likely to become diseased, unless brought into full

use by exercises which necessitate deep and full respiration. Runners always have large and active chests, and sedentary persons have chests of limited capacity and rigid walls.

Probably the best of all exercises for developing the breathing powers is swimming. The position of the body and the active movements of the arms and legs make swimming a most effective breathing exercise. The contact of the skin with the cold water also stimulates the movements of the chest, while, by increasing the energy of the muscles it produces vigorous muscular movements. Even the ordinary daily bath is an excellent means of enlarging respiration. It deepens the breathing, and this in time results in greater lung capacity. It also increases the circulation of the blood in the lungs, which means greater absorption of oxygen. The daily cold bath, by increasing the resistance of the body, prevents colds, which are injurious to the respiratory passage and other more serious diseases of the lungs. In experiments made with young people the girth or size of the chest was increased in some cases one and one half inches in three weeks as a result of cold bathing.

We need a large amount of air. We require a pint of air at every breath. If you can take more, it is all the better. A consumptive often does not take half that. A pint every breath, sixteen breaths a minute, equals two gallons every minute; that amounts to 120 gallons an hour, almost 3000 gallons a day. Three

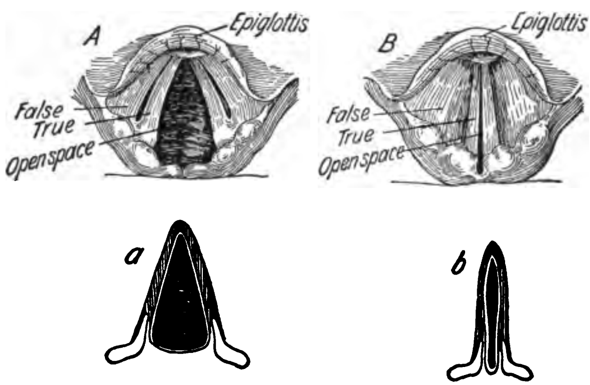
thousand gallons would be how many barrels?— nearly 100 barrels of air. That is the daily ration of air.

Special breathing exercises, as well as those muscular movements which create a "thirst for air," are beneficial to the lungs by keeping the chest flexible and ventilating the lungs. These movements also exercise a beneficial effect upon the digestive organs lying below the diaphragm, as we saw in a previous chapter. Every time the diaphragm contracts it gives these organs a hearty squeeze, so to speak, emptying out the blood contained in them, as one may empty a moist sponge by pressure upon it. All exercises which increase the strength of the abdominal muscles are a means of aiding and improving the breathing.

One should make a practice of taking some kind of breathing exercises for a few minutes several times a day. They should of course be taken outdoors where the air is pure. A convenient time is on the way to and from school. Simply filling the lungs with air until every part is expanded and then slowly exhaling it is very beneficial. Do this several times in succession. When you are tired or feel dull and stupid, try the effect of going outdoors or opening a window and taking a few deep breaths. You will be surprised to see how this will rest and refresh you and sweep the cobwebs from your brain. After being shut up in a close room or in an ill-ventilated hall or church, be sure to ventilate the lungs thoroughly on coming out by

taking a few deep-breathing movements. Tiredness, nervousness, and mental cloudiness are usually driven away by the increased ventilation of the body secured by deep breathing.

Care should be taken that the breathing movements are in no way interfered with by the clothing. Corsets or tight belts are likely to restrict the action of the rib



THE LARYNX.

A and *a*, the vocal cords in resting position; *B* and *b*, the vocal cords in position for producing voice.

muscles and so tie the handles of nature's bellows, the lungs.

The voice. The vocal cords are, as we have seen, situated in the larynx, at the entrance to the windpipe. "Adam's apple" will show you just where the larynx is located. Within the larynx are two bands of tissue which run across the side walls from the front to the back. When the vocal cords are brought

together and air is forced through them, sound is produced. The pitch of the voice depends upon the weight, length, and tightness of the cords. Change of pitch is brought about by the tightening or loosening of the vocal cords. In a stringed instrument, such as a violin, a heavy string gives a lower tone than a light one. In strings that are the same weight, a short string gives a higher tone than a long one, and, in those of the same weight and length, a tight string gives a higher tone than a loose one. In like manner when the vocal cords are long and loosely stretched the voice is low in pitch. When the cords are short or tightly stretched the pitch is high.

A grown person has a larger larynx and hence longer vocal cords than a child, and consequently a voice of lower pitch. The change of voice in a boy between the ages of fourteen and eighteen is due to the enlargement of the larynx, which takes place especially at that period. Do you think the voice should be given severe use while it is changing? A man has a larger larynx than a woman and hence a voice of lower pitch. When men and women are singing together the voices of the men are an octave lower than those of the women.

Speech is produced by modifying the voice by means of the tongue, teeth, lips, and throat. In whispering, the usual movements of the mouth are made, but the vocal cords are not used.

An important means of preserving the voice is to

avoid taking cold. If a cold has been taken, the voice should not be used in singing or loud speaking until the hoarseness is relieved. Permanent injury to the voice sometimes results from disregarding this rule. The use of rich foods and irritating condiments injures the voice, by producing a congestion or chronic inflammation of the throat. Smokers are especially liable to disease of the throat on account of the hot, irritating smoke brought into contact with the delicate vocal cords.

In speaking, and especially in singing, the muscles of the waist should be used. Increased force as well as greater volume may be given to the voice by the use of the abdominal muscles, and the voice will then be much less easily fatigued. A high-pitched, strained voice should be avoided, as it is irritating to the throat, tiring to the speaker, and disagreeable to the hearer. Those who have not learned the use of the abdominal muscles in speaking or singing, habitually use the muscles of the throat and upper part of the chest in a strained way during loud speaking and singing greatly to their injury. You should cultivate full tones, using the muscles of the waist instead of the upper part of the chest. See if you can tell what muscles you usually use in speaking and singing.

Health Problems

1. Do the various groups of workers in the community in which you live exchange their products with one another? Suppose

there were no such exchange; what would happen in your community? Would something of the same thing happen if there were no exchange among the different cell groups in the body?

2. Point out where your larynx, your trachea, your "Adam's apple" are situated.

3. Show what happens to a breath of air, taking it from the very start and following it until it comes out of the body. Tell the organs that it passes in the body, the things that it does in the body, and the changes that come to it.

4. Have you ever had a bit of food go down your windpipe a little way? Describe your experience when this happened.

5. What arrangement has nature provided so that if food goes the wrong way the body will try to throw it out. Will the body do this without your directing it? Why?

6. Feel your lungs when you are breathing deeply and tell how it is possible for them to expand as they do and then contract. Are there 2000 square feet in the floor of the room in which you are now? Can you imagine that the membrane in the lungs would cover 2000 square feet?

7. Why is there so much mucus when you have a "cold"? Why does the nose run so freely when one is breathing a good deal of dust?

8. Can you tell your veins from your arteries by their color? If so, describe the difference in color.

9. See if you can bring to school some device that acts like a piston and show just how it works. Show that air is sucked in when the piston is moved.

10. Explain coughing; how does it differ from breathing? What is a hiccough? What is yawning? What is sighing? Sobbing? How does laughing differ from regular breathing?

11. See if you can tell with what part of your lungs you habitually breathe. If you try, can you breathe with the entire lungs?

12. Suggest some good exercise to strengthen the abdominal muscles.

13. What does it mean to knead the stomach? Why is it proper to speak of the action of the diaphragm as kneading the contents of the stomach?

14. Do you think you could permanently prevent yourself from breathing by effort of will? Why?

15. Explain why the voice of a boy of fourteen or fifteen changes.

Review Questions

1. What is the meaning of the "breath of life"?

2. What is the great purpose of breathing?

3. How do the cells packed far away in the body get their oxygen?

4. What is meant by "division of labor" among the cell groups in the body?

5. What is the means of communication between the lungs and the cells throughout the body?

6. What is the use of oxygen in the body? How does it get through the lungs into the body?

7. Describe the breathing apparatus, telling about the parts and their uses.

8. How much space would the membrane in the lungs cover if it were spread out on a flat surface?

9. What is meant by *air* passages?

10. Where are the *tonsils* located? What are their uses? What may happen when they become swollen and diseased?

11. Why do people sometimes have tonsils cut out from their throats?

12. How has nature arranged it so that the air we breathe goes to the lungs and the food goes down the esophagus to the stomach?

13. With what is the breathing apparatus lined? How does this lining assist in keeping good health?

14. What are the cilia, and what do they do to help the body keep in health?

15. What happens to the color of the blood as it passes through the lungs? Through the capillaries?

16. Where does the carbon dioxide which escapes from the lungs come from?

17. What is the color of the blood in the arteries? In the veins? Explain.

18. How are the lungs ventilated?

19. Describe the cavity in which the lungs are placed.

20. How does the diaphragm act so as to help one to breathe?

21. What is the meaning of inspiration? Expiration?

22. To what can one liken the act of breathing? Why?

23. Why is there a movement of the entire lungs when one breathes correctly?

24. What is the reason why some people breathe through the mouth?

25. What is the effect upon one's health and mind of breathing through the mouth?

26. What should be done for one whose air passages are stopped up with adenoids? Why?

27. How does breathing assist digestion?

28. Does one breathe as heavily or rapidly during sleep as when he is awake? Why?

29. What is the effect of alcohol upon the lungs?

30. Why is it desirable to have large lung capacity?

31. Mention ways in which it is possible to enlarge the lung capacity. What is said about the value of running, swimming, the daily cold bath, and so on, in developing lung capacity?

32. Suppose one does not stretch his lungs to their full capacity quite frequently, what may happen to them?

33. Where are the vocal cords located? Describe them.

34. What is the difference between the vocal cords of a grown person and those of a child?

35. How is speech possible?

36. How is it possible to change the pitch in one's voice?

37. What may happen if one strains the voice while he is hoarse?

38. What muscle should be used especially in speaking and singing?

CHAPTER VIII

How the Body Cleanses Itself

In a community of people living together, there is always a certain amount of waste matter to be disposed of. In a well-regulated city the garbage or waste is daily removed from the houses and other offensive waste matters are carried away by means of sewers. If wastes are not promptly removed, but allowed to accumulate, the health of the people will be in danger.

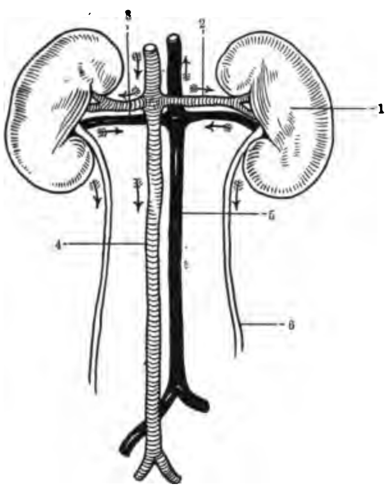
Organs of excretion.

We have found that the cells that make up the body community not only take in food and oxygen, but they also send out waste matters into the lymph that surrounds them. Of course, the health of the cells depends upon the prompt removal of these wastes. The work of sending them out of the body is called excretion, and the cell groups that do the work are called the organs of excretion or elimination.

There are four organs by means of which waste and poisonous matters are got out of the body. Two of these we have already considered: the intestine, which removes the indigestible parts of food and some wastes from the digestive organs; and the lungs, which carry

off the carbon dioxide. The other two organs are the kidneys and the skin.

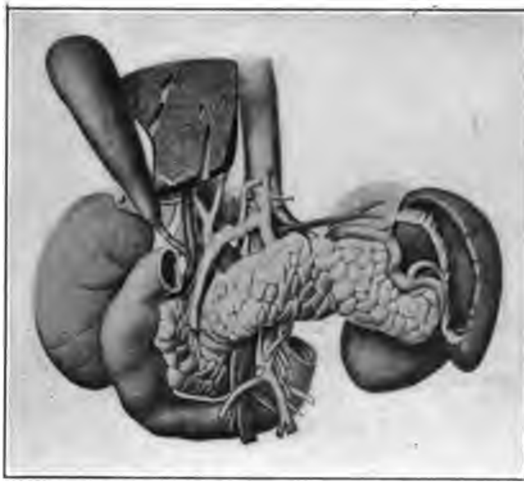
When fuel is burned in a stove, the greater part of it passes off up the chimney in the form of gas and smoke, but a small portion remains behind in the form of ashes. The same thing takes place when food is burned in the body. Fats and carbohydrates are changed by burning into gaseous poison (carbon dioxide) and water. The gaseous poison escapes through the lungs, which are the chimney of the body, and each of the organs of excretion carry off some of the water. Water is constantly being given off from the lungs and the skin. The moisture in the breath may be seen out of doors on a cold day; and when the body is overheated the perspiration becomes visible upon the skin. A certain amount of water also passes off through the intestine. The kidneys are, however, the chief means of removing any excess of water from the blood. The combustion of proteid



THE KIDNEYS PLAY AN IMPORTANT PART IN RIDDING THE BODY OF WASTES.

1, kidney; 2, renal artery; 3, renal artery; 4, descending aorta; 5, ascending vena cava; 6, ureter.

foods produces, besides carbon dioxide and water, a certain amount of wastes, which correspond to the ashes that are left behind when the food is burned in the stove. These wastes, after being prepared and made soluble, are extracted from the blood and sent out of the body by the kidneys. A small amount of both the gaseous poison and other wastes passes out through the skin in the perspiration.

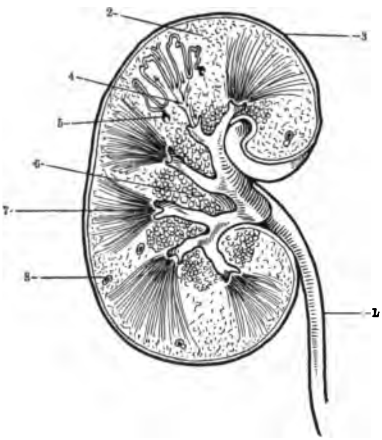


WITHOUT THESE ORGANS OF EXCRETION THE BODY WOULD BE COMPLETELY POISONED IN A FEW HOURS.

These important organs of excretion are located at the back part of the abdominal cavity, just below the lower ribs. They are placed close to the spinal column, one on each side. Each kidney is a gland shaped like a kidney bean, and weighs from four to six ounces.

Examined under the microscope, the substance of the kidney is found to be made up of very delicate tubes, which begin near the surface of the organ in delicate little round sacs. Each sac contains a

minute blood vessel coiled up. These tubes combine as they pass towards the center, becoming larger in size and finally opening into a cavity in the kidney. This cavity communicates with a long tube, called the bladder, from which it is discharged from time to time. The kidney excretion (the urine) contains some of the most poisonous waste elements of the body. When from any cause the action of the kidneys ceases, death soon takes place.



A CROSS-SECTION OF THE KIDNEY. NOTICE THAT THE SUBSTANCE OF THE KIDNEY IS MADE UP OF DELICATE TUBES WHICH COMBINE AS THEY PASS TOWARD THE CENTER.

1, ureter; 2, cortex; 3, capsule; 4, tubule; 5, renal corpuscle; 6, fat; 7, pyramid; 8, blood vessel.

The kidneys are always at work, but are more active at some times than at others. Anything that increases the flow of blood through the kidneys stimulates them to greater activity. Drinking freely of water is beneficial to the kidneys. It dissolves the poisons and aids the kidneys in removing them. In summer, especially, when a large amount of water passes off through the skin in the perspiration, it is very necessary to drink a sufficient amount of water to make good the loss from this source.

Overeating, especially of protein foods, the waste products of which it is the business of the kidneys to remove, increases the work of the kidneys, and is likely to overtax them. The kidneys are in close sympathy with the skin. Both remove from the blood water and wastes. Whatever interferes with the work of the one will impose extra labor upon the other. Sedentary habits, neglect of bathing, exposure to severe cold, and excessive use of flesh foods may be mentioned as the chief causes of kidney diseases, which are rapidly increasing in our country.

Things that injure the kidneys.

Alcohol injures the kidneys, as it does the liver and all other parts of the body with which it comes in direct contact. It causes inflammations and changes which finally result in the disease and decay of the organs. Disease of the kidneys is very frequent among beer drinkers. The free use of ale and beer excites the kidneys to excessive action until they become worn out.

It is a part of the work of the kidneys to remove from the blood poisonous substances formed in the stomach and intestines as the result of indigestion, and to carry out of the system food substances which have been taken into the blood without being perfectly digested. The liver, as we have seen, completes the work of digestion. When it becomes disabled by the use of alcohol, some portions of the food are allowed to pass into the general circulation without having

been so changed by the liver that they can be used by the cells in building up the body. The removal of these useless substances adds greatly to the work of the kidneys.

We see, then, what a chain of mischief is started by the use of alcohol.

1. Alcohol renders the stomach unable to digest food properly and so throws extra work upon the liver.

2. Alcohol injures the liver so that it cannot perform its ordinary duties, besides putting upon it the double labor of removing the alcohol and endeavoring to complete the imperfect work done by the stomach.

3. The kidneys are not only disabled by the alcohol but are compelled to remove a portion of it from the body, as well as the poisonous and unusable substances resulting from the injury to the stomach and liver.

One evil resulting from the use of alcohol creates another, and so the evil is multiplied.

The skin.

The chief purposes of the skin are: (1) To form a protective covering for the body, in order to prevent the entrance of harmful substances, such as germs. (2) To regulate the heat of the body, keeping it at a constant temperature. (3) To receive impressions of heat, cold, pain, and so on. (4) It also, to a small extent, as we have seen, assists the lungs and the kidneys in the work of excretion.

You may remember that this outer layer of the skin is called the epidermis. This is a covering for the

dermis, which contains the active parts of the skin, — the glands, nerves, and blood vessels, — by means of which the various kinds of work of the skin are carried on.

The flattened cells which compose the outer layers of the epidermis are all the time drying and scaling off and so the skin needs to be constantly renewed by the

A SECTION OF THE OUTER LAYER OF THE SKIN.

making of new cells. We have learned how the cells multiply, by each cell's dividing into two new cells. The cells in the lower layers of the epidermis divide in this way and form new cells to take the place of those that have been thrown off.

Since the epidermis has for its purpose the protection of the delicate parts beneath it, it is thickest in those regions of the body where there is the most pressure. On the soles of the feet and the palms of the hands

there may be as many as one hundred layers of epidermal cells, while on other parts of the body there are not more than twenty. Constant pressure upon any part of the skin causes a great increase in the number of epidermal cells at that point. A corn on the foot is due to the thickening of the epidermis resulting from the pressure of the shoe.

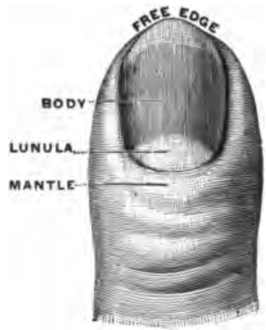
The hair and nails are curious horny structures which grow out from the skin. Hairs are found upon all parts of the body, with the exception of the palms of the hands and the soles of the feet. Each hair grows from a small, deep pocket in the skin, called the hair follicle. Both nails and hair are constantly being formed in the dermis and pushed upward. The uses of the hair seem to be to protect the parts beneath from changes of temperature, as in the case of the head; to protect sensitive parts from dust and other harmful substances, as in the eyelashes and eyebrows, and the hairs of the nostrils; and to aid the sense of touch.

Opening into the hair follicle are one or more sebaceous glands, which pour out an oily substance to moisten the hair, to lubricate the skin, and to protect it from drying and chapping. The color of the hair is due to pigmented cells like those which give the skin its color.

The nails grow from a little fold in the skin and from the tissues over which they lie. They protect the ends of the fingers and toes, increase the delicacy

of the sense of touch, and aid the fingers in picking up small objects.

The inner layer of the skin, the true skin or dermis, contains many blood vessels, glands, and nerves, and also minute muscles connected with the hairs. When one is chilly these muscles sometimes contract, causing a rough appearance of the skin commonly called "goose flesh."

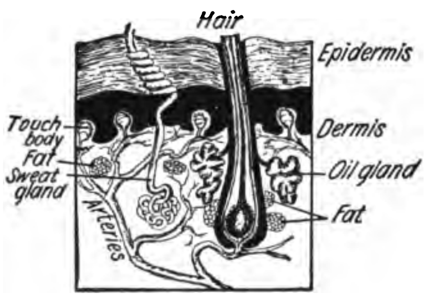


THE PROPER CARE OF A NAIL.

The outer surface of the true skin is not flat, but is thrown up into moundlike projections called papillæ, which project up into the epidermis. Some of the papillæ contain blood vessels and some of the nerve endings of the sense of touch. The large number of blood vessels with which it is provided give the skin such vitality that small wounds in it will heal very rapidly, if one's blood is healthy. Even when quite a large surface of the skin is removed, new skin will grow out from the edges until the gap is entirely covered.

It is very important that the skin, being the protective covering of the body, should be kept from injury. Even a small opening in the skin, such as a slight scratch, may open up a way for a deadly germ, which may cause serious and even fatal results. Of course, wounds in the skin should be cleansed with a disinfecting fluid and kept covered.

The work of the sweat glands, of which there are in the skin not less than two and one half millions, is to cool the body by pouring out water upon the skin. This they are doing constantly, but the amount of water is usually too small to be noticeable. It evaporates before it becomes visible and so is called insensible perspiration. The amount of insensible perspiration produced daily by the entire skin is usually from one and one half to four pints. It is by the evaporation of the perspiration that the body is cooled. Exercise or heat greatly increases the amount of perspiration so that it becomes visible upon the skin and is known as sensible perspiration.



THE SWEAT OR PERSPIRATION GLANDS.

While the perspiration is not really an excretion, but a heat-regulating secretion, it is at the same time a means by which some of the waste matter contained in the blood is carried out of the body. Around the lower part of a sweat gland are many blood capillaries from which an abundant supply of lymph escapes. We have found that lymph contains gaseous poisons and other waste substances discharged into it by the cells. When the water of the lymph passes through the walls of the sweat glands, it carries with it a small quantity of these wastes,

which are thus discharged from the sweat gland in the perspiration.

When the water evaporates from the surface of the body, the waste matter it contains remains on the skin and becomes mixed with oil from the sebaceous glands, dead epidermis, and dust from the air and the clothing. If this is not regularly removed by bathing and friction of the skin, it will form a thin coating all over the body, and will give off a bad odor and interfere with the work of the skin. Where there is dirt, there are germs. An unclean condition of the skin encourages the growth of germs upon it, and some of them may get down into the hair follicles and the sebaceous glands, and cause pimples and other skin eruptions.

Health Problems

1. How are the various wastes in your community got rid of? Are there as many groups of persons attending to this work in your community as there are groups of cells attending to similar work in your body?

2. Suppose any group of persons in your community who remove wastes should cease to do their work, what would happen to the people? Such things often happen in communities; have you ever known of such a case?

3. Show that the burning of food in the body leaves something like the ashes left from the burning of wood in a stove. Suppose the ashes in a stove or a furnace should not be removed at all. What would happen in time to the fire? Is it the same in the body?

4. Do you know whether people who eat a great deal of meat and live a sedentary life are troubled with kidney diseases? Ask

your physician this question. If he tells you that such people are likely to have kidney diseases, ask him why and remember what he says.

5. Ask a physician the same question in regard to people who drink a good deal of wine, beer, or whisky, and be careful to get exactly what the physician says.

6. Suppose a person who lives indoors should eat three meals a day composed largely of beans, cheese, lean meat, milk, and eggs. Should you expect such a person to keep well? Explain.

7. Suppose the liver and the kidneys could express their feelings when a man was about to take a glass of whisky, what do you think they would say, and why?

8. Enumerate the different ways in which one may illtreat his kidneys. Do you think they should be treated as friends rather than as slaves? Why?

9. What is the greatest enemy which the body has? Be prepared to give reasons for your opinion.

10. Suppose you should cover the surface of your body with wax, what do you think would happen? Would it be about the same if you should let the body be covered over with the wastes thrown out by the skin?

11. Why is there no hair on the palms of one's hands or the soles of his feet? Do you think the hairs on the back of the hand are of any use to the body?

12. Explain how it is possible for one after a hot foot bath to rub off considerable of the outer skin of the feet. Why is there so much of this skin on the feet?

13. Think of some way to show that the sebaceous glands contain an oil which they pour out to keep the skin from becoming hard and dry.

14. Why is it that people who live in hot countries where there is a great deal of sunshine have black hair, while people who live in northern countries where there is not so much sunshine have lighter colored hair?

15. Have you known of any fatal diseases to be due to injury to the skin? If so, describe them, and say whether with right treatment the victims could have been saved.

16. Think of some way to show that there is invisible perspiration pouring out from the skin all the time.

17. What is the best way to take a warm bath? Mention injurious ways of taking baths which are sometimes adopted by people.

Review Questions

1. What name is given to the work of sending wastes out of the body? To the organs which have charge of getting rid of wastes?

2. What are the wastes formed by the burning of food in the body?

3. How is the gaseous poison, carbon dioxide, got out of the body?

4. What waste does the skin take out of the body? What the kidneys?

5. Where are the kidneys located? What is their shape?

6. Describe what one sees when he looks at the substance of the kidneys through a microscope.

7. What happens when the kidneys cease to do their work?

8. What will increase the action of the kidneys?

9. Suppose the skin does not do its work. What is the effect on the kidneys? Why?

10. What effect do the following have upon the kidneys: over-eating (especially protein foods); the skin's failing to do its work; severe cold; neglect of bathing; sedentary habits; and using alcohol.

11. When the food is not digested properly, do the kidneys suffer? Why?

12. Give the "chain of mischief" started by the use of alcohol.

13. Name the four chief purposes of the skin.

14. What is the outer skin called, and what is its use? What is the inner skin called, and what is its use?

15. What happens to the epidermis when it is rubbed by the shoes, for instance?

16. What is the connection between the hair and nails and the epidermis? What is the name of the pockets in the skin from which the hair grows?

17. What is the use of the sebaceous glands?

18. What are the papillæ? To what use are they put?

19. Why is it necessary to be careful not to injure the skin?

20. How should wounds in the skin be cared for?

21. What is the work of the sweat glands?

22. What is the meaning of insensible perspiration? Of sensible perspiration?

23. When water evaporates from the surface of the skin, what does it leave behind?

24. Why is it necessary to bathe frequently?

CHAPTER IX

How the Temperature of the Body is Regulated

Whether we are shivering with cold in the winter or perspiring in the warmest weather, a physician's thermometer placed in the mouth will show that the temperature of the body inside is exactly the same at both times. The power to maintain a certain temperature under all the different conditions of life is one of the most remarkable of the powers of the human body. The internal temperature of the body is constantly maintained at about 98½ degrees F. At all seasons and in all countries the variation in temperature when one is in health is scarcely more than one degree. This is more wonderful when we consider how greatly the temperature of the air may vary at different seasons and in different countries,—from 70 degrees below zero in Arctic regions to 130 degrees above in the sultry deserts of northern Africa.

The temperature of the body.

Things without life, such as a stone or a piece of earth, usually have the temperature of the surrounding air. Many living creatures do the same thing. The temperature of a frog, a snake, a turtle, or an earthworm differs little from that of its surroundings.

The only creatures which have this great power of maintaining a constant temperature in spite of changes in the surrounding air are mammals and birds. These animals are called warm-blooded, because they are usually warmer than surrounding objects; and animals that have not this power are called cold-blooded, because they usually feel colder to the touch than do warm-blooded animals.

As we have already learned, the heat of the body is produced by a slow combustion of food; and this is taking place all the time. This combustion goes on chiefly in the muscles and is much more active during exercise than when the body is at rest. Yet the internal temperature of the body during rest and moderate exercise is the same, although much more heat is produced during exercise. The loss of heat from the body takes place chiefly at the surface, through the skin. A great deal more heat is lost from the body when the surrounding air is cold, yet the body temperature remains the same. By what wonderful means is the body temperature so perfectly arranged that it remains the same under all these different conditions?

How the body temperature is regulated.

Think of two ways in which you may regulate the temperature of a room. If the room becomes too warm, you open a window or door to let some of the heat escape. If the room is too cold, you poke up the fire, put on more fuel, or open up the stove draughts so that more heat will be produced. You may control the tempera-

ture of a room by regulating the amount of heat that is produced or by regulating the amount of heat that

IF THE ROOM IS TOO WARM YOU OPEN THE WINDOW TO LET SOME OF THE HEAT ESCAPE.

escapes. The temperature of the body is regulated in the same way.

The marvelous work of regulating the temperature of the body is done, not by one organ alone, but by

several working together under the direction of the nerves. The nervous system is the real regulator of the body temperature, but the work is done by means of the three organs: the muscles, the blood vessels, and the sweat glands.

The process of heat-making which is carried on in the muscles is regulated by certain nerve centers in the brain and spinal cord, which are connected with the muscles by nerves, so that the making of heat is under constant and perfect control. When the body is exposed to cold air or water or is in any way cooled so that the temperature of the blood is lowered, nerve centers in the brain incite increased activity in the heat-making organs and more fuel is burned in the cells. In this way the heat-making process is adjusted to the needs of the body.

When the cooling of the body is continued to such a point as to produce a considerable fall in the temperature of the blood, one usually feels chilly and begins to shiver. "Shivering" consists in a rapid contraction of the muscles in which nearly all the muscles of the body take part. As muscular action is always accompanied by the making of heat, this is an automatic method of warming the body. Shivering is simply a natural method by which the body is exercised in order to increase the amount of heat production.

The loss of heat from the body is chiefly at the surface, and the device for controlling it is in the skin. There are two ways in which the skin controls the

escape of heat from the body. One is by regulating the amount of blood that comes out into the skin. The blood carries the heat from the warm interior of the body to the surface, where it is cooled off in the skin. The temperature of the skin is always much lower than the internal temperature and seldom rises above 92 degrees or 93 degrees. After cooling, the blood is carried back to the interior of the body. In this way the blood equalizes the body temperature, and keeps it from becoming too hot in some parts and not warm enough in others.

When the body is exposed to cold, the blood vessels of the skin contract and shut out the blood, allowing only a small quantity to pass through. The blood is thus kept in the warm interior of the body. When the blood becomes too hot, the blood vessels of the skin open up and allow a large amount of blood to pass out into the skin where it becomes cooled. This is the cause of the flushing of the face and sometimes even of the whole body, when it is exposed to a warm atmosphere.

Through these changes in the circulation of the blood in the skin, the heat loss may be increased to three or four times the usual amount or lessened to the same extent.

The other method by which the skin regulates the loss of heat is by the work of the sweat glands. We have already learned that the body is cooled by the evaporation of perspiration. Now evaporation cannot

take place without heat. A liquid in evaporating must take up heat from surrounding objects. You may easily demonstrate this by wetting one of your hands then holding both hands in a current of dry air. Why does the wet hand become so much cooler than the dry one? You may make the same experiment by wetting one finger and noticing how much cooler it becomes than the rest of the hand. If alcohol or ether, which evaporates much more quickly than water, is used, the cooling off will be much more marked. In the evaporation of a pound of water as much as one thousand heat units are absorbed; that is, as much heat is consumed in the evaporation of a pound of water as would be required to raise half a ton of water one degree in temperature. About two and one half pounds of water are evaporated from the skin daily, representing a heat loss of about two thousand five hundred heat units, or one-fourth of the amount of heat generated in the body. The heat loss may be greatly increased by exercise or exposure of the body to cool air.

The wonderful power of the sweat glands to protect the body from injury by excessive heat has been shown by some experiments in which men remained for some time in a room heated to 260 degrees or forty-eight degrees above boiling point. Meat was being cooked by the heated air of the room, an egg was roasted hard in twenty minutes, and water soon boiled; but the men, although very uncomfortable, remained un-

injured, without even a rise of temperature. The two million little sweat glands of the skin were hard at work all the time to save them. The evaporation of the water which they poured out upon the skin in great quantities cooled the skin and prevented it from becoming cooked, as it would otherwise have been.

In order for the evaporation of the sweat to take place freely, the air must be dry. Why? In moist air, when there is little or no evaporation of the sweat, there is little cooling of the body by this means. For this reason, one is much more liable to suffer with heat in a moist atmosphere, on a "muggy" day, for instance, than in a dry atmosphere.

A small amount of heat escapes from the body in the breath and by the evaporation of moisture from the lungs and air passages. This is why a dog, which does not sweat, pants when overheated, either from exercise or from hot air. By the act of panting, the air is rapidly passed in and out of the lungs, and the increased evaporation cools the dog's blood.

So constant must be the body temperature in health that any variation from the normal, 98½ + degrees, gives cause for anxiety. As a result of some shock or in one who is very feeble, the temperature may fall below normal, through insufficient heat production or too great an escape of heat. More often there is a rise of temperature above the normal, and then one is said to have a fever. In fevers, heat production and

loss are not so perfectly controlled as in health, because the heat centers are disturbed by the poisons circulating in the blood. The sweat glands are not so active as usual, and the surplus heat does not escape.

When one has a fever, the temperature may be reduced by sponging the body with water, the evaporation of which will carry off some of the surplus heat. A hot bath or pack may be given to excite the activity of the sweat glands.

The heat-regulating functions of the body are not under the control of the will. One cannot start or check the perspiration or cause the surface blood vessels to contract or dilate by an effort of will. We may, however, now that we know how heat is produced in the body and how it escapes, do various things to increase or lessen heat production or heat loss.

Active exercise.

By active exercise, for instance, we can greatly increase the amount of heat produced. One exposed to the cold does not usually stand still. He walks or runs about, stamps his feet, claps his hands, swings his arms, and engages in all sorts of muscular activities that increase heat production. In very warm weather, one is, on the other hand, much less active. In the warm countries, the hottest part of the day is usually passed in sleep, reducing as much as possible the amount of heat production.

Heat production is also determined by the quantity and quality of the food. In the Arctic regions, men live largely on fat, which has the highest heat value of

any food, while men of the tropics live largely on rice, and fruits, which have a low heat value. A larger quantity of food is required in the winter than in the summer, especially by one actively exercising out of doors. Why, do you think?

Living in heated homes.

The escape of heat from the body in cold climates is greatly lessened by the custom of living in heated houses. Some animals burrow into the ground and make themselves nests in which to pass the winter. No animal but man, however, provides itself with artificial heat. This practice has many advantages, but it also has some disadvantages. What are they?

Do you think there is any danger from overheated rooms? Have you noticed that one is very likely to take cold in passing from a hot room into the cold outdoor air? Explain. Overheated rooms also have a weakening effect upon the system. The skin becomes relaxed, and the body more sensitive to cold. The heat-making powers in people who live in very hot rooms or houses are likely to lose some of their vigor, for lack of exercise.

Cold rooms, or rooms insufficiently heated, may also have injurious effects because too much heat may be lost from the body. When the body is chilled, and the surface blood vessels contract, the blood is forced in upon the organs within and these are liable to become congested.

The best room temperature is 68 degrees F. The

circulation of the blood will then be well balanced. There will be no excess of blood in the skin or in the internal organs, but it will be properly distributed between them.

When the skin is heated from exercise or a hot atmosphere, the blood vessels it contains become filled with the blood that is forced into them. If a person in this condition, covered with perspiration, sits in a draught or a cool place, the blood vessels in the skin will contract and the blood will be forced inward. Some part of the lining membrane of the body, usually the nose, throat, or lungs, will be liable to become congested with blood, and a cold will be the result. The white cells in the congested blood vessels will lose their vigor and become inactive, and the microbes may get the upper hand and make mischief. For this reason, a person who has a cold is likely to take other diseases to which he is exposed.

Colds, their cause and cure.

The best thing to do when a cold is coming on is to increase the activity of the skin as much as possible. This may be done in several ways: (1) By vigorous exercise which will bring every sweat gland into activity; (2) by a hot foot bath or a full bath, which will expand the surface vessels and bring the blood to the skin; (3) by drinking freely of hot water or hot lemonade, which will aid in starting a good perspiration.

When the blood is drawn to the surface of the body, the delicate internal organs are relieved of the excess

of superfluous blood that causes the congested condition.

After the hot bath, a short cold shower or a quick cold rub should be taken; or a pailful of cool water may be poured over the body. This will stimulate the nerves of the skin and prevent the taking of cold afterwards. It will also stir up the white blood cells to greater activity and so assist in the work of getting well again.

Saving heat loss by clothing.

Another way in which human beings living in cold countries have learned to lessen the escape of heat from the body is by clothing. The natural clothing of the body is the skin and hair. This is true of man as well as of other animals. Savage tribes who live in the mild climate to which man is naturally adapted find little or no clothing necessary for either comfort or health.

But experiments have shown that it is not possible for the body to maintain its temperature if exposed without clothing to air at a temperature of less than 86 degrees F. The temperature in which an individual actually lives is that of the air next to the body, inside of the clothing. Clothes lessen the loss of heat from the body by keeping it in a jacket of still air, which is an exceedingly bad conductor of heat. Each additional garment makes another "air jacket." For this reason, several thin garments are much warmer than one thick one, just as a house with double walls and windows, inclosing a layer of air, is warmer than one

with single walls and windows, though they may be of double thickness. When one throws off a garment he at the same time removes one of his "air jackets."

Sufficient clothing should be worn to maintain the temperature of the air in contact with the body at from 77 to 86 degrees F. This requires for the ordinary man about six to eight pounds of clothing in the summer, and twice as much in the winter season if he is exposed to the outdoor temperature. Those who live indoors in heated rooms require very little more clothing in winter than in summer, while they remain indoors.

Animals regulate their skin clothing to suit the season, growing a thick cover for protection in the winter season and shedding their thick hair in the spring.

A matter of the highest importance is the arrangement of clothing on the body so that there shall not be too much heat in certain parts, while other parts are not sufficiently protected. The arms and legs, and particularly the feet, require special protection, for the reason that they are farthest from the heat centers, while they present a larger surface for heat loss in proportion to their weight and the amount of blood supplied to them than does the trunk. Many persons suffer greatly and are often made sick from insufficient clothing of the limbs in the cold seasons, without being aware of the cause of their illness. When the arms and the limbs are chilled, their blood vessels will

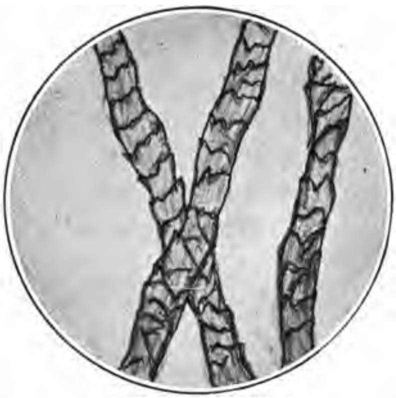
be contracted, and consequently some internal part will get more than its share of blood. Congestion of the head and various troubles with the internal organs may result from this source.

The material of which clothing is made has a very important relation to health, because different fabrics behave very differently in regard to letting heat escape from the body, taking up moisture and permitting air to circulate about the body. Linen absorbs moisture much more rapidly than does wool and dries more than twice as quickly. This is also true of cotton to a less degree and to a still less degree of silk.

Cotton has a flat and twisted fiber that can be manufactured into a much more elastic cloth than can linen, the fibers of which are cylindrical, straight, and stiff. Wool fiber has a jagged, scale-like surface, and is soft and so elastic that it is difficult to produce from it a compact thread, and when woven the cloth furnishes a great number of air spaces between the meshes. Clothing made from wool is both very warm and very light. Wool garments, however, are very likely to shrink and "full" when washed, unless very carefully laundered. In that

COTTON HAS A FLAT AND TWISTED FIBER.

case, the air spaces between the meshes and the elasticity of the fabric are diminished, until it sometimes happens that undergarments and hose of all wool after frequent washings become almost air tight, which is very bad for the body, as you know.



WOOL HAS A JAGGED, SCALE-LIKE SURFACE.

As the skin is constantly throwing off moisture, it is very important that the clothing should be able to take it up and pass it out to the air. Woolen goods hold the moisture for a long time. Wool is on this account not well adapted for garments to be worn next to the skin. Cotton is superior to all other fabrics for this purpose. Linen stands next in value. The fact that the quick drying of linen or cotton exposes the skin to rapid cooling by evaporation necessitates the wearing of outer garments of wool to prevent the too rapid loss of heat during those seasons of the year when extra precaution is required.

The wearing of cotton next to the body is conducive to cleanliness. Cotton undergarments prevent undue heating of the skin and accumulation of moisture, the latter of which has the effect to relax the skin and

keep in a moist and decomposing state the waste matters thrown off by it. Cotton may be worn at all seasons of the year. It is only necessary to provide sufficient outer clothing to secure the necessary warmth. An additional thick union suit will afford better protection than extra outer wraps.

Health Problems

1. See if you can get a physician's thermometer and find out your internal temperature. The physician will tell you to put the thermometer under your tongue. Why would it not do to put it on the surface of your body?

2. Take your temperature if you can on a hot day and on a cooler day to see whether the temperature varies according to the weather.

3. Get the temperature of a frog or a snake if you can on a warm day and on a cooler day. Does the temperature change with the weather? Explain.

4. Mention a number of warm-blooded animals. Mention a number of cold-blooded animals.

5. Suppose you were out in the open air and the temperature of the air should drop thirty or forty degrees. What would happen if you had no extra clothing to put on? Explain.

6. Suppose one could not shiver when he was chilly. Would this be any disadvantage to his body?

7. Why is there so little blood at the surface of the body when one first goes out on a cold, biting day? Why is there so much heat at the surface of the body when it is a hot day?

8. Explain why it is that people who live in cold countries are often large and "ruddy," while people who live in warmer countries are often thin and pale.

9. Tell the class some way to show that evaporation takes heat. Think of some way not mentioned in your lesson.

10. Show in some simple way that evaporation from the skin cools it.

11. Think of some way in which you could make it plain to a person what it meant to raise half a ton of water one degree of temperature. Figure out what you could do with the heat required for this, if you could collect it all and use it just as you wanted to.

12. Is it a good thing to have very dry air in winter when one wants to keep warm? Is it a good thing to have moist air in summer when one wants to keep cool?

13. Why does one feel colder where there is a wind than he does where it is quiet, even though the thermometer may be the same in both places?

14. Why are the people in northern countries usually more active than those in the tropics?

15. Have you noticed that you are often cooler on a hot day when you play or work than when you lie around in the house? Explain.

16. Have you ever noticed that when you have been in a room in winter up to 80 degrees, you will feel chilly when you go out into cold air? Explain.

17. See if you can find out what is usually the cause of your colds. How do you treat your colds? Do you take patent medicine, cough drops, and the like?

18. Show why storm windows help to keep a house warm, even when there is no wind.

19. Suppose you could have an undergarment woven so that you could not possibly see through it, and could have another which was porous, and they were both the same weight, which would you choose? Why?

20. Try soaking a piece of wool, a piece of cotton, and a piece of silk in water until they are thoroughly wet. Then take them

out and see which one will become dry the more rapidly. Explain.

Review Questions

1. What would happen to the body if the internal temperature should change very much?

2. How is the warmth of the body kept up?

3. Where are the heat-making processes in the body carried on chiefly? How is the amount of heat made in the body regulated?

4. How does the body protect itself from undue heat or cold?

5. Tell particularly about the work of the sweat glands in regulating the loss of heat.

6. Tell about the experiment made by the men who stayed in a room heated to 260 degrees F.

7. What sort of air must one have in order that the sweat may evaporate freely? Why does one usually feel uncomfortable on a muggy day?

8. Why is it that in a fever the temperature of the body becomes higher?

9. What is a good way to reduce the temperature of the body when there is a fever?

10. What is the influence of exercise upon the making of heat in the body?

11. Why does one usually feel inactive on a very hot day?

12. How does the kind of food one eats affect the heat-making in his body?

13. Why is one likely to take cold when he lives in houses that are very hot?

14. What is likely to happen to one when he stays in a room that is very cold?

15. What happens to the internal organs when one has a cold?

16. Why should one always follow a hot bath with a cold spray or a dash of cold water?

17. How does clothing help to prevent too great loss of heat in the body? Just how is clothing able to keep the body warm?

18. Why is it better to wear several light garments in winter than one very thick and heavy one? What sort of clothing is best to be worn next to the skin?

19. What parts of the body should be clothed particularly well in winter and why?

20. What kind of clothing should be avoided? Why?

CHAPTER X

The Framework of the Body

Some of the work of the body — that of supporting itself — is too heavy for the soft cells to do alone. They therefore build up around themselves solid structures, in much the same way as a snail builds its house, and a turtle its shell, out of its own body. Bone and cartilage, which make the solid framework of the body, are formed in this way.

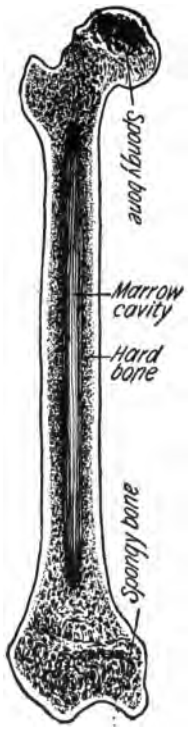
The nature and uses of the bones.

The skeleton of a new-born baby is composed wholly of cartilage, which, as you know, is not so hard as bone. It is so pliable that the bones of a little child may be easily bent.

The bones are gradually hardened as they grow by the bone cells building lime into them. By the time they are full grown only a thin layer of cartilage on the ends of the bones remains. In order that they may be properly developed, the food, especially of young children, should contain a sufficient quantity of lime. Milk and whole-wheat bread are good bone-building foods. Why?

If the lime or mineral matter is dissolved out of a fresh bone by acid the animal part that remains will

be found so flexible that if the bone is long and slender, it may be easily tied in a knot. The more lime there is in the bones, the less pliable and the more brittle they become. The proportion of lime in the bones seems to increase from year to year through life. For this reason the bones of aged persons are very easily broken.

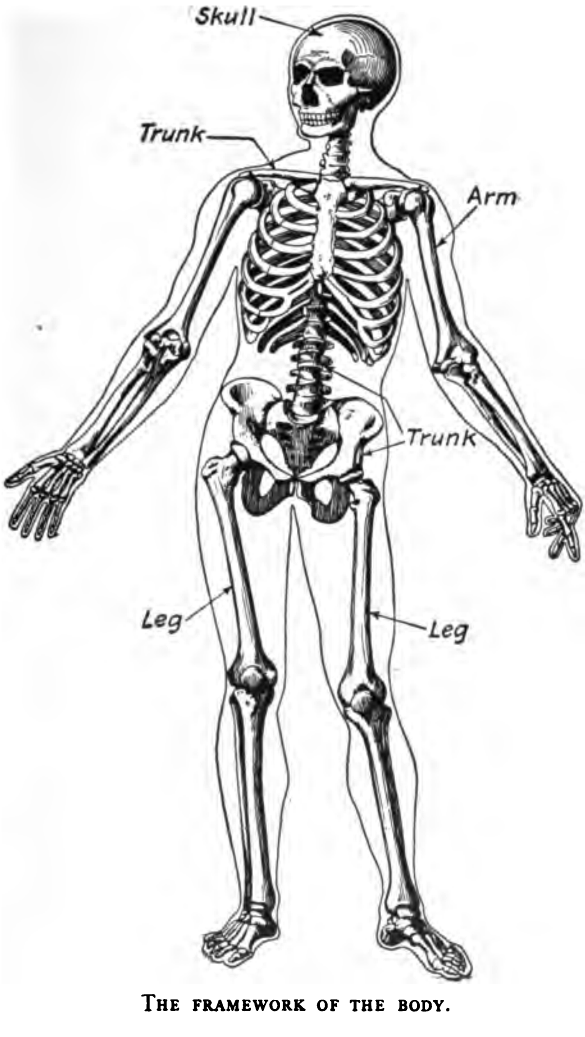


LONGITUDINAL SECTION OF THE FEMUR.

Bones are covered by a tough membrane called the periosteum, which contains a few nerves and numerous blood vessels through which the bone is nourished and developed.

If the large bones of the human body were solid, they would be very much heavier without being much stronger. Of course, you see it is necessary they should be not only *firm* and *strong* but light enough to be easily moved. If you look at the picture of a cut through a long bone, you will see that it is only the outer layer that is composed of solid bone. Of what is the inner layer composed? You should note especially that in the middle there is a canal or hollow space.

Do you see that cavities in the bones not only give lightness, but they also increase the strength of the bones? Can you explain why?



THE FRAMEWORK OF THE BODY.

An experiment with a sheet of paper and a book will show that when the paper is rolled into a hollow cylinder, it will support more weight than in any other form. Mention other instances in which nature makes use of this device to secure a combination of lightness and strength. Think of some ways in which man makes use of this same fact.

It is in the bones that the red corpuscles of the blood are formed. The cavities of the long bones are filled with a substance called marrow, containing nerve and blood vessels and large quantities of fat, which gives it a yellow color. In the smaller cavities of the spongy bone the marrow contains less fat and is of a red color, because it is here that the red corpuscles are being formed.

Without a skeleton, the body would not be able to hold itself upright. One of the chief uses of the bones is, therefore, to support the body.

It is easy to see, is it not, that without the bones the various movements of the different parts of the body, as in walking, raising the arms, would not be possible? The bones aid in moving the body and its various parts. Each bone has roughened places and ridges to which muscles are attached, and the bones thus provide levers by means of which the muscles are able to move the body.

Another important use of the bones is to protect from injury the delicate and sensitive parts of the body. You can feel the strong box that the bones of

your head form for the protection of your brain. The spinal cord into which the brain passes is guarded by the bony tube called the *spinal column*. You can feel also the strong framework of bone that protects the lungs and the heart.

THE SPINAL COLUMN.

The body of a new-born baby has as many bones as that of a full-grown man — 206. They are of different sizes and shapes, according to the use that is to be made of them. Some are long, as those in the legs and arms; some short, as in the wrist; some flat, as in the upper part of the skull; some curved, as in the ribs. You can feel most of your own bones and decide for yourself why each has its own particular shape. By studying the picture of the skeleton and comparing it with your own body, you can easily locate all the principal bones and find out, if you wish, the names that have been given to them.

The most important and interesting of the bony structures of the body is the spinal column. It is necessary that it should be strong enough to support the trunk and the head and protect the spinal cord. At the same time, it must be flexible enough to bend with ease in any direction with the movements of the trunk, yet in such a manner that the delicate spinal cord within it shall not be injured. This wonderful combination of uses is accomplished by the arrangement

of a number of separate ring-like bones, one above another, bound together with bands of strong connective tissue known as ligaments. These bones are called the vertebræ. The bony column with a canal running through it, which is formed by the twenty-four vertebræ when they are arranged one above the other, is shown in the illustration.

Buffers to prevent jarring in the body.

The vertebræ are separated from each other by means of disks composed of very elastic cartilage. These act as buffers to prevent friction and jarring which might injure the brain. A person who is much on his feet becomes shorter during the day by the thinning of the cartilages between the vertebræ; but he regains his height during the night. Most persons are half an inch taller in the morning than at night.

You will notice in the picture that the spinal column is not straight but forms a graceful double curve. It is upon the preservation of the natural curves of the spine that the poise and graceful carriage of the body chiefly depend. These curves also aid in giving springiness to the spinal column and so preventing jarring of the head in walking or running.

Notice the difference in the amount of jar the body receives in jumping with the legs straight and stiff and with the legs bent at the knees; also the difference in the jarring of the hand when the ground is struck with a straight stick and with a curved one. The curves in the spine, the arch of the foot, and the bend-

ing of the knee, as well as the cartilages separating the vertebræ, all aid in protecting the brain by giving greater springiness to the skeleton and so preventing jarring.

If the spinal column is broken it is quite impossible to stand or walk, since there is no support for the trunk, and the spinal cord which controls the movements of the muscles is injured. It is, however, so flexible that such an accident rarely happens.

The joints.

If the bony framework of the body were all united in one piece, no movement of the different parts of the body would be possible. If, on the other hand, it were composed of disconnected bones, there would be no support for the body as a whole and it would not be able to stand upright. It is necessary that the bones should be joined together, but in such a way that the free movements of the parts should be possible. The places where the bones are united are called joints.

Where great strength but no movement is required, the bones are solidly united by immovable joints. Since there is no movement at these joints, we cannot detect them in our own bodies, but they may easily be seen in the skeleton of the head for instance. Most of the bones are united by movable joints. Why, do you think?

In an immovable joint, the bones are firmly united by a piece of cartilage that grows between them. In a movable joint, a thin layer of cartilage covers the

end of each bone, and this is kept lubricated, or moist, by an oily fluid poured out by a delicate membrane that incloses the joint. This enables the joints to work very smoothly and noiselessly.

The joints are bound together by tough bands of connective tissue called ligaments. Besides holding the bones together, these ligaments also limit the movements of the joints.

BALL-AND-SOCKET JOINT.

There are several kinds of movable joints. In the ball-and-socket joint, the rounded end of one bone fits into a cuplike hollow in another bone. This kind of joint is found in the shoulder and the hips. It gives the greatest freedom of motion, allowing movement in all directions, as you may see by swinging your arms or legs. Hinge joints, examples of which are found in the elbow and the finger, allow movement only in two opposite directions. In gliding joints, the bones move slightly upon each other, as at the wrist and ankle.

The vertebræ have a special kind of joint. They rock back and forth on each other, as they are pulled by the muscles that control them, the amount of

movement being limited by the ligaments that hold them together.

In consequence of a fall or a blow, the end of a bone is sometimes dislocated or "put out of joint." The ligaments about the joint are broken, and the bone slips out of place. On the occurrence of such an accident, a physician should be called at once, before the parts become swollen. Why will they swell?

Injuries of the bones and joints.

A sprain is an injury due to a strain of a joint resulting in a ligament's being torn from its fastenings to the bone. Bathing in water as hot as can be borne will keep down the swelling and relieve the pain. Why? Elevation of the injured member will also help to keep down the inflammation. Why?

THE WRIST JOINT.

When a bone is broken, the muscles often draw the ends of the broken bone apart and a physician is required to put them in proper position. There may be sharp points on the ends of the broken bones, which are likely to tear the tissues if the limb is bent at the broken point. On this account, great care should be taken to keep the limb perfectly straight until the physician arrives. After being "set," the ends of the bone must be held in position by splints and bandages until Nature has time to cement the parts together

by means of a jellylike substance produced between and around the ends of the broken bone. This substance gradually hardens and becomes as firm as bone, making the bone nearly as good as before.

The effects of tobacco poison in preventing the proper development of the bones is so marked that even those who allow its use by adults condemn its use by growing boys. We have already seen that the heart, the lungs, and the digestive organs are injured by tobacco, so that no part of the body gets its proper supply of food and oxygen. The bones suffer as well as the rest of the body from this lack. Besides this, the tobacco poison seems to have a special effect in injuring the bone cells and checking the development of the bones. A boy who early begins to smoke cigarettes is almost sure to be dwarfed and stunted in body as well as in mind.

Keeping straight.

If you should fasten the bones of a skeleton together with artificial joints and then try to make it stand upright, you would find you could not do so; it would all fall together in a heap of bones. There must be something besides the joints to hold the bones together and keep them in their proper position. This work is done by the muscles. The skeleton could no more stand alone without the aid of the muscles than the muscles could stand without the skeleton.

It is of great importance that every group of muscles in the body should be properly developed so that the

NAMES OF MUSCLES

a - *Occipito Frontalis*
b - *Temporal*
c - *Masseter*
d - *Sterno-Cleido-Mastoid*
e - *Deltoid*
f - *Pectoralis Major*
g - *Pectoralis Minor*
h - *Obliquus Externus*
i - *Rectus Abdominalis*
j - *Biceps*
k - *Triceps*
l - *Gluteal Muscle*
m - *Rectus Femoris*
n - *Sartorius*
o - *Abductor Muscles*
p - *Biceps Femoris*
q - *Vastus Externus*
r - *Tibialis Anticus*
s - *Extensors of the Toes*

NOTICE AT WHAT POINTS SOME OF THE MORE IMPORTANT MUSCLES ARE ATTACHED. EXPLAIN.

skeleton may be held erect. It should be supported equally on every side, like the masts and spars of a full-rigged vessel. This is necessary in the first place in order to have a good appearance.

We bear in our bodies a sort of record of our habits

WHAT SORT OF A HABIT IS THIS BOY FORMING?

AND THIS ONE?

that may be easily read by a trained eye. A slouching body and a shuffling walk create a most unfavorable impression of carelessness, laziness, and lack of dignity and self-respect. A boy who walks with head erect and shoulders well squared gives an impression of energy and self-respect which is of great advantage

to him. A girl with a fine carriage and graceful walk makes a much finer appearance than one who neglects to hold herself erect and who walks with a careless gait.

We are in some respects the architects of our own bodies. It is more or less in our power to determine the shape of the body. Especially in youth when the bones are pliable and the muscles supple, we may, according to our habits, influence the position of the bones and their relations to each other. We may then determine whether we shall have a well-shaped body and erect carriage that will at once recommend us to others or an awkward carriage and ungainly body that will always be a handicap to us.

DO YOU APPROVE OF THIS BOY'S WALKING HABIT?

The symmetrical development of the body is of even more importance for the sake of health than for that of a good appearance. An external deformity

usually means a corresponding internal deformity; the latter is of far greater importance than the former. Round shoulders, for instance, are always accompanied by a flat chest. This means the lungs will be compressed and therefore the breathing capacity will be lessened.

How deformities are caused.

It is only by exercise that the suppleness of the body, the elasticity of the muscles, and the flexibility of the tendons and ligaments can be preserved. If the muscles of a certain part of the body are not used in such a manner as to stretch them, they may become shortened and, after this, stretching them will be impossible. If the arm be kept bent for a long time, it may become impossible to straighten it, because the muscles of the inner surface of the arm will have become shortened through not being stretched. This illustrates how deformities may be produced through the pulling out of place of the bones, which may be permanently held there by a shortening of the muscles.

The vertebræ of the spinal column are moved by the contracting and lengthening of the muscles attached to them. When the spine is curved on the left side, the muscles on the right side contract and are shortened, and a curvature of the right side means a shortening of the muscles on the left side. When the body, in sitting, standing, or working, is habitually held in an improper position, some of the muscles may become permanently shortened, causing a life-long deformity,

known as spinal curvature. A backward curvature of the spine, manifested by round shoulders, a flat or hollow chest, forward carriage of the head, and an unnatural straightness of the back, is by far the most common form of spinal curvature. If the muscles of the back are relaxed, the spine naturally falls backward by its own weight. This is what makes the chest flat. The trouble is not in the chest, but in the spine, and the curvature of the spine is due to the relaxation of the muscles of the back allowing the spine to bend backward.

WHAT MAY HAPPEN TO ONE WHO GETS IN THE HABIT OF SITTING BENT OVER A TABLE OR A DESK?

HEALTH PROBLEMS

1. Suppose a boy five years old and one twenty years old should fall from a limb of a tree, say a distance of twenty-five feet. Do you think it probable that either boy would break the bones in his leg or in some other part of his body? Which do you think would be most likely to escape injury? Explain.

2. Suppose you put a man of fifty in place of the boy of five,

which one of the persons falling would then be most likely to suffer?

3. Suppose that the boy of five, the young man of twenty, and the man of fifty years should each break the bones in his leg. Which one of the three persons do you think would recover soonest?

4. If you had to break a bone in your arm or your leg, at what age should you choose to have it occur, if you could have your choice? Explain.

5. It was said in this chapter that the bones of a child are soft. Do you think Nature planned this for a particular purpose? If so, mention it.

6. Try the experiment of taking the lime out of a bone and notice what happens to it.

7. Try the experiment of burning the animal part out of a bone and notice what happens to it.

8. Can you give a reason why the red corpuscles should be made in the marrow of bones?

9. Suppose you had a non-flexible spinal cord. What should you be prevented from doing that you can now do?

10. Try the experiment of trying to hold your body perfectly stiff and then jump up and down on your heels, though not very high, of course. How do you feel? What reason can you give for this experience?

11. In your own body point to some immovable joints. Why did nature not make them movable? Why did she not make them in one piece so that there would be no joints?

12. A boy I know had his leg broken in a football game. He did not have the surgeon come at once. It is now six months since the accident occurred, and the break has not yet healed, though he is a healthy boy. What do you think might be the explanation of this?

13. Mention some deformities in people which could have been avoided by good habits of sitting, standing, and walking.

Review Questions

1. How does the body secure a framework to support itself?
2. What makes up the framework of the body?
3. Of what is the skeleton of a new-born baby composed?
4. What is the cause of such a deformity as knock-knee and bowleg?
5. What makes the bones hard? Give a description of each part of which the bone is composed.
6. What kind of food do young children need in order to build their bones?
7. What is the periosteum?
8. Why did nature not make the large bones of the body solid?
9. How does nature secure lightness and strength in bones?
10. What are the uses of the skeleton?
11. What is the arrangement so that the muscles can move the bones?
12. How many bones are there in the human body? What are their shapes?
13. What is the spinal column?
14. How is the spinal column made so that it is very flexible?
15. What are the bones in the spinal column called?
16. What is the use of the disks that separate the vertebræ?
17. Why is a person taller in the morning than he is at night?
18. Of what value is it to have the double curve in the spine?
19. What are the ways in which Nature tries to prevent too great jarring of the brain when one walks, runs, or jumps?
20. If the spinal column should be broken, what would happen to the body?
21. What is the purpose of the joints that join the bones together? What is meant by immovable joints? Mention some of these joints. What is meant by movable joints? Mention some of these.
22. What is the use of the ligaments in the body?

23. Give an example of the ball and socket joint; of the hinge joint; of the sliding joint.

24. What does it mean to have a bone dislocated?

25. What is a sprain? How should you treat a sprain?

26. What should be done in case a bone is broken?

27. What is the effect of tobacco on the bones?

28. What is needed besides bones and joints to keep the body upright?

29. Can we do something toward securing good appearance? If so, what can we do?

30. What does a slouching body and a shuffling walk indicate in a person? What does a fine carriage and graceful walk indicate?

31. What usually accompanies any external deformity?

CHAPTER XI

The Body in Motion

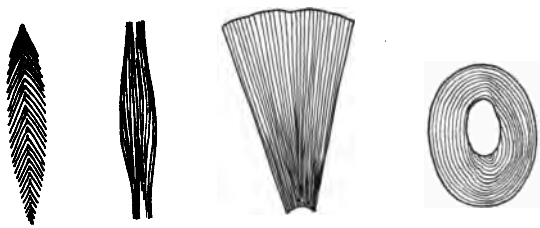
The living machinery by means of which all the movements of the body are made is the muscular system. Every movement of a living creature is made by means of muscles. The flight of a bird in the air, the rapid moving of an insect's wings, the gliding of a snake along the ground, — all animal movements of whatever kind are made by muscles.

Without the muscles, man, if he could live at all, would be quite unable to express his thoughts or feelings or to communicate them in any way. Why? Even those changes of the features which we call expression are due to the play of the delicate muscles of the face, which by their action pull the skin of the face about this way or that, as may be necessary to express thoughts and feelings. The fine tones of the orator, the pleasing notes of the singer, the marvelous skill shown in piano playing, in drawing, and in various arts, all depend partly upon the action of the muscles. This is true of a large part of all the experiences of human life.

There are two kinds of muscles in the human body,

those which are under the control of one's will, called voluntary muscles; and the involuntary muscles which one can not control by just willing to do so. Five hundred pairs of voluntary muscles are the servants of one's will in performing the different kinds of work of which the body is capable. The number of the involuntary muscles is too great to be estimated. The skin is a perfect network of little muscles. Every hair has a minute muscle attached to it by means of which it may be made to stand erect.

Kinds of muscles.



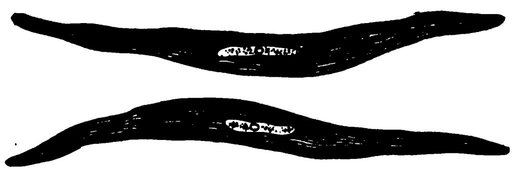
MUSCLES HAVE DIFFERENT SHAPES.
1, feather; 2, spindle; 3, fan; 4, ring-shaped.

The stomach is a muscular sac, the intestines a muscular tube, the air tubes of the lungs have muscular walls, and the heart, the great pumping organ of the circulation, is a wonderful muscular engine.

All these involuntary muscles act according to the needs of the body and quite independent of one's will. They are at work for us when we are asleep, as well as when we are awake, keeping the heart beating and the lungs active. When food is swallowed, it is seized by the involuntary muscles and carried into the stomach, worked upon, and moved from point to point until it is digested. By means of these muscles, the blood is

circulated and the supply to each part is regulated. All their work is done with faithfulness and loyalty to the well-being of the body, even when the voluntary muscles controlled by the will are working against the body's interests. Think of some instances that will illustrate this.

The muscles are of different shapes and sizes, according to the work for which they are designed. Some are shaped like a spindle, some like a feather, some like a fan, and still others are ring shaped.


Muscle fibers.

The cells which compose the voluntary muscles are the largest and most active in the entire body. They are called muscle fibers, because they are long, slender, and threadlike. They have the power to contract, or draw themselves up as a worm does in crawling, so that they become shorter and thicker. These muscle fibers are held together by a sheath of connective tissue, which divides the cells into groups and ties them up into bundles.

The lean part of meat is muscle. A piece of lean corned beef, boiled, may be easily separated into small bundles. These bundles may, by the use of needles, be separated into bundles still smaller. These last small threads are the muscle fibers.

Nearly all the voluntary muscles are attached to

the framework of the body, the skeleton, because the bones are the levers by means of which movements are made. Each muscle is usually attached at two points. The point which is less movable, or which is nearest the center of the body, is called the origin, and the other the insertion. At the end of each muscle, a continuation of the connective tissue sheath is joined to the periosteum, thus attaching the muscle to the bone. Nearly every muscle is joined in this way to two separate bones, passing over the joint; so the muscles are an important means of holding the bones of the skeleton together.

How muscles are attached to bones.

The connective tissue does not always pass directly from the muscle into the periosteum. Sometimes the tissue forming the sheath unites at one or both ends to form a white cordlike structure called a tendon, by means of which it is attached to the bone. Some muscles have tendons at each end, some at the point of insertion only, and still others have none at all.

Sometimes the point of insertion, or the place where the tendon is attached to the bone, is at some distance

from the muscle itself. If all the muscles necessary to give to the hand its strength and variety of movement were attached directly to the bones of the hand, it would be very heavy and clumsy. The hand and the foot are moved by muscles in the arm and leg, to which they are attached by long, slender tendons. Why? When the hand is opened and closed, the tendons which attach the fingers to the arm muscles

WHY DO THE MUSCLES STAND OUT SO CLEARLY IN THE ARMS AND BACKS OF THESE BOYS?

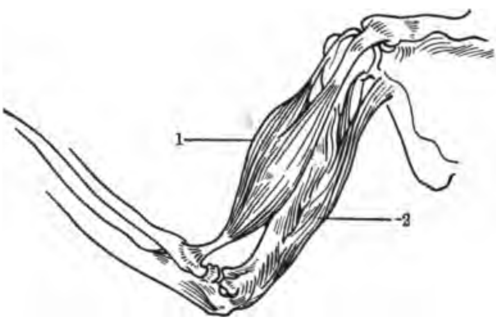
may be seen in the wrist, and the movements in the muscles in the arm may be distinctly felt.

How muscles act.

It is of more importance to us to know how muscles act and what are the relation of their action to the work and needs of life than to know the particular names that have been given to the muscles and to the bony parts to which they are attached.

When the cells of a muscle contract, the whole

muscle is shortened. In shortening, each fiber thickens, so that there is no change in the actual size of the muscle but only in its form. The shortening of the muscle causes it to pull upon the bone to which it is attached, and this results in the bending of the joint over which the muscle passes, and a movement of some part of the body. You can easily see all this for yourself by placing your hand upon the large muscle in the upper arm (biceps) and noticing the shortening and thickening of the muscle by means of which the arm is bent at the elbow when the hand is raised.



ANTAGONISTIC MUSCLES IN THE ARM: 1, biceps; 2, triceps. Point out the biceps and triceps in the picture of the boys on page 195.

The muscles can by their contraction only pull on the bones. The biceps muscle can pull up the forearm, but it cannot push it back into place. It has to be pulled back by another muscle. If you bend your arm at the elbow and place your hand upon the back of the upper arm while you straighten it out again, you will feel the tightening of the triceps muscle which pulls down the forearm and holds it in place.

A great many of the voluntary muscles are arranged in pairs of antagonistic muscles, working against each

other in the way the biceps and triceps do. Antagonistic muscles, with their steadying pull, one against the other, act as brakes which keep the movements from being jerky and spasmodic, as they otherwise would be. Most of the movements, as those of the arms and legs, — even the simple act of standing erect, — require the action of many muscles, each of which is balanced by some other one, thus enabling us to perform steady and graceful movements.

Keeping muscle tone.

If a muscle is cut, it will immediately shorten up like a piece of rubber on a stretch. The muscle is always more or less stretched or taut when it is alive and healthy. This tension in the muscle is what is called muscle tone. The muscle tone is kept up by a stream of energy pouring into it from the nerve centers. When one is tired out, this energy is exhausted, the muscles lose their tone, and there is a relaxed condition. That is why a person who is tired or weak lets his head droop and his chest collapse. When one goes to sleep in a sitting position, the head "nods" or drops forward, because the muscles that held it in position become relaxed; that is, they lose their tone.

We can feel and see the contraction of a working muscle, but there is another important change taking place in it that we can neither see nor feel. As the muscle begins to contract, its arteries dilate and fill with blood, for it is the blood that brings to the muscle the energy that it requires for work. A working

muscle is warmer than one at rest, for the reason that muscular contraction is always accompanied by the burning up of some of the food material which is stored in the muscle and brought to it in the blood.

When any large group of muscles, for instance those in the legs, are set in active operation, as in jumping or running, one very quickly gets out of breath. This is fatigue. It is due to the fact that when the muscle is at work, it throws into the blood which passes through it a large quantity of carbonic acid gas, which is poison to the body and must be hastened out through the lungs. The greater the amount of this gas thrown into the blood, the quicker one becomes out of breath and the more rapid the breathing movements become. Then the lungs are expanded to their utmost capacity. Why?

In running a long race the runners do not start off at full speed. Why?

If the exercise is less violent, but continued for a

longer time, one may not get out of breath, but after a while the muscles will become wearied, so that movement is difficult and may become impossible. This fatigue, or exhaustion, is due, not to the using up of the muscle's store of energy, but to the formation of those poisonous substances that result from the muscle work, which we have already studied, and which have a harmful effect upon the muscle.

The muscle is a machine which may be compared to a locomotive, since it carries its own fuel. This fuel is stored up in the muscle in the form of glycogen, or animal starch, which in use is converted into sugar. In work, the sugar is converted into carbon dioxid and lactic acid. These products are muscle poisons. As work continues, the oxygen and glycogen stored up in the muscle are lessened and the poisons accumulate. This hinders the muscle in its work. It is in the situation of a locomotive whose fire is choked with ashes while its fuel is low. This is real fatigue.

Exertion may be carried to such a point that death may result from the fatigue induced. Runners have sometimes dropped dead at the end of a long course. Horses have been known to die suddenly from the same cause, as have dogs also when attempting to follow their master on a long bicycle ride. Carrier pigeons not infrequently fall to the ground dead from exhaustion after a long and rapid flight. In such cases, death is due to the rapid accumulation of the poisons formed by too prolonged action of the muscles.

It is interesting to notice that exercising a part of the body may cause the whole body to become fatigued. For example, one's arms may become tired as the result of running. Show how this can be possible. How can the poisons formed in the leg muscles get to the arm muscles?

Every movement of a muscle is made in response to an impulse which it receives from the nerves. From the brain or the spinal cord a nerve goes to every voluntary muscle in the body. Prolonged muscular work wearies the brain and nerves, as well as the muscles, partly by reason of the fatigue poisons circulating in the blood. One is much more likely to become fatigued when performing exercise to which he is not accustomed. Why? When he becomes used to the work it can be done with less effort and the amount of fatigue poison formed is less. Why?

If one who is fatigued will rest for a time, the feeling of fatigue will probably disappear. Rest generally cures fatigue and puts the muscles in trim for work again. Rest gives the muscle an opportunity for increasing its store of oxygen and glycogen and also for the washing out by the lymph and blood of the poison with which the muscle has been filled by work.

Curing fatigue.

A very short hot bath will lessen fatigue, because it will stimulate the circulation of the blood and so hasten the removal of the fatigue poisons. A prolonged hot bath will aggravate the feeling of fatigue, and it may

even produce a feeling of exhaustion. Why? A short cold bath will also relieve fatigue through its general stimulating effect upon the body. One may fortify himself against fatigue by cold bathing, by providing the muscles with an abundant supply of muscle starch or glycogen and with plenty of oxygen by deep breathing of pure cold air.

After effects of fatigue.

After prolonged and violent exercise, especially exercise to which one has not been accustomed, one may find himself suffering from muscular soreness and stiffness, together with a feeling of great lassitude. These feelings do not usually appear until some hours, perhaps a day or even longer, after the exercise producing them. This is called secondary fatigue.

The fatigue caused by a short period of exercise is soon recovered from and may disappear within a few minutes. The longer and the harder the work performed, the longer the period of rest required. The soreness and stiffness which accompany secondary fatigue usually disappear in a few days. Unless the exercise has been exceedingly violent so that the parts used have been strained or injured in some other way, the muscles are then stronger than before and able to endure more work, and the same exercise may be repeated without injury. The soreness and stiffness which follow the first attempts with any new form of exercise should not discourage one. They should be regarded as an indication that Nature is preparing the

muscles for better service by strengthening the muscular fibers and storing up a larger amount of energy.

Man is designed by Nature to be the most agile, enduring, and active of all the members of the animal creation. A healthy child can with difficulty be restrained from almost constant activity when awake. The amount of work which can be performed by the body is much greater than is usually supposed. From what you have learned, should you not say that the human body is one of the most perfect working machines in existence? It makes more economical use of the food taken into it as fuel than does the most improved form of locomotive. The body is able to use one fourth of its food fuel in energy, with three fourths going to the production of heat; whereas the most economical steam engine can use only about one sixth of the energy of the fuel, with five sixths being wasted as heat.

Health Problems

1. Which of your actions occur without your knowing it? Was there a time when they would not occur without your being conscious of them? Explain.

2. See if you can locate in your own body the different shaped muscles referred to in this chapter. See if you can explain why each muscle has the shape you find it to possess.

3. Take a piece of lean meat which has been thoroughly boiled and separate it into muscle fibers. Be careful that you do not stop with bundles of fibers.

4. Point out some muscles that pass over joints. Why do they go over the joints?

5. See if you can trace two or three muscles from origin to insertion.

6. Locate some of the tendons in your hands or feet or elsewhere in your body if you think you can find any.

7. Why did nature make tendons? Why did she not fasten the muscles directly to the bone which she wanted to move by them?

8. Suppose the triceps in the right arm be cut. How would the arm behave? Explain.

9. Make the experiment of closing your fist as tight as you can and then opening it quickly and repeating with great rapidity as long as you can. Describe your experience. If you should reach a point when you could not close the fist longer, explain why this should happen.

10. What kind of work tires you most easily? Explain. What do you do to get over fatigue? Can you cure this condition quite easily?

11. Describe some experience of yours which has made your muscles stiff the day afterward. Explain.

12. Write an essay on keeping the muscles in good working condition.

Review Questions

1. What is the living machinery in which the movements of the body are made?

2. Mention the various activities which we can execute and which require the use of the muscles.

3. What is meant by the voluntary muscles? By the involuntary muscles?

4. How many pairs of voluntary muscles are there in the human body? How numerous are the involuntary muscles?

5. What do the involuntary muscles do for one that he needs to have done in order to keep in health?

6. Are the involuntary muscles more faithful than the voluntary muscles? Why?

7. What are the different shapes and sizes of muscles?

8. Describe a muscle fiber. How are the muscle fibers arranged in the muscles?

9. What part of meat is usually composed of muscle fibers?

10. How are the muscles attached to bones? What are the names of the points of connection of muscles with bones?

11. Describe a tendon and say for what it is used.

12. Why did nature think it necessary to make tendons? In what parts of the body may they be felt by the fingers?

13. What happens when the cells of the muscles contract?

14. How is it possible that the muscles can move a bone?

15. Where is the biceps muscle? Where is the triceps muscle?

16. Why are the muscles arranged in pairs working against each other?

17. What will happen to a muscle when it is cut?

18. What does it mean to keep up *muscle tone?*

19. Explain why a person who is tired lets his head droop and his chest collapse.

20. What change in the character of the blood takes place in a muscle when it contracts? What is the purpose of this change?

21. Why does one get out of breath when he is running or jumping?

22. What does it mean to become fatigued? Does one become fatigued because his muscles wear out or from some other cause? May overwork of one muscle fatigue the whole body? Explain.

23. What may happen to a person if he exerts himself until he is completely exhausted?

24. From where do the impulses which cause muscles to move come?

25. What kind of work is likely to fatigue one most readily?

26. What is the best way to relieve fatigue? What is the value of hot and cold baths in relieving fatigue?

27. What causes secondary fatigue?

28. Is it truthful to say that the human body is the most perfect working machine ever devised?

CHAPTER XII

Feeling and Thinking

If a community of people are to live and work harmoniously together, they must have some kind of government, of course. The body community must also have its government. The ruler of the body is the mind working through the nervous system.

It is in response to commands sent out through the nervous system that the digestive organs begin to work when food is eaten; that the lungs and heart work faster to increase the breathing when we run, so that a greater amount of oxygen may be carried to the muscles; and that the skin pours out perspiration to cool off the body. The nervous system brings all the cells and organs into communication, causing them to work together for the common good.

There are two forms of nerve tissue: nerve cells and nerve fibers. The nerve fibers are really additions to the cells, or parts of them. Most nerve cells send out two or three slender arms, one or more of which may be prolonged into nerve fibers; and others connect with the branches of other cells or end in the spaces between them. As you see in the pictures, a

nerve cell with its branches is called a neuron. A careful examination of the branches shows that they are covered with minute buds. It is supposed that these buds are for the purpose of communicating directly or indirectly with other cells.

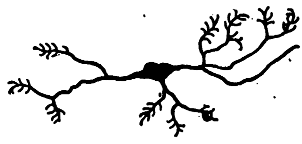
Do you see how the mind working through the brain, spinal cord, and nerves can control all parts of the body?

The nerve cells are usually found in groups, and each group has its own particular work to do in the government of the body. A group of nerve cells having some special work is called a nerve center or ganglion.

The little bundles of nerve fibers which pass out from a nerve center unite to form larger bundles, which pass to the different parts of the body. When the body of an animal is dissected, white, glistening cords are found running everywhere among the tissues. These bundles of nerve fibers are called nerves or nerve trunks.

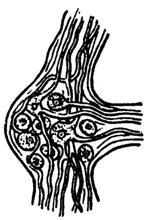
There are two divisions of the nervous system, just

as there are two of the muscular system. All the involuntary muscles, those not under the control of the will, are governed by what is called the sympathetic nervous system. The voluntary muscles are controlled by the central nervous system.



A NERVE CELL.

The brain and spinal cord are the great centers of the nervous system. In the brain lies the power by which we feel, think, and will. The brain is simply an assemblage of nerve cells or neurons, hundreds of millions of them. With the exception of the whale and the elephant, the brain of man is larger than that of any other animal.



A NERVE GANGLION.

The spinal cord enters the cranium and connects with the brain through a large opening at the base of the skull. It is a soft white substance, about the thickness of a pencil or a little thicker. It passes through the backbone, which forms a protection for it, and it is also protected by membranes like those which cover the brain.

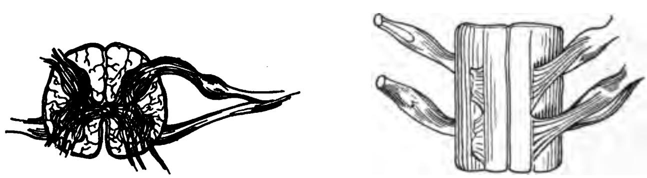
The brain and the spinal cord send out nerves to the different parts of the body, forty-three pairs in all. Twelve of these arise from the under side of the brain and are called cranial nerves. They pass through small openings in the base of the skull and are distributed to the face, the organs of sense, — eye, ear,

THE SYMPATHETIC NERVOUS SYSTEM.

nose, and mouth, — and to the organs of the chest and abdomen. Thirty-one pairs of spinal nerves pass out from the spinal cord through openings in the side of the spinal canal. The spinal nerves are distributed to the trunk and the extremities of the body.

How we feel and think.

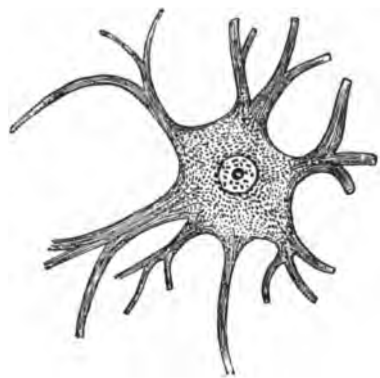
The nerves are for the purpose of carrying messages between the different parts of the body and the brain and spinal cord. The cell branches, as well as the matter composing the center of the cell, consist of transparent jellylike matter as clear as water, yet possessing the most wonderful properties



TWO VIEWS OF A SECTION OF THE SPINAL CORD.

of any known substance. By means of these living threads, which are many times smaller than the finest spider web, the nerve cells of the different parts of the

body are in constant communication with one another, just as various points and cities of a country are in communication by means of telegraph and telephone wires. The brain is the central office which connects all the different parts. If all the other structures were removed, — such as the skin, bones, blood vessels, muscles, — and nerve fibers and cells only were left, the form of the body would still be complete in appearance. What does this suggest to you? The thinking and feeling organs, the brain and nerves, really occupy the whole body, just as do the circulating organs, the heart and blood vessels. Does this mean that there is nothing but brain and nerves in the body? What does it mean?



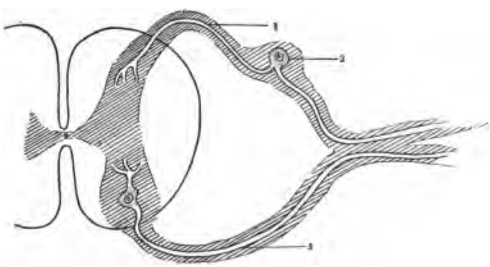
A NERVE CELL FROM THE SPINAL CORD (MUCH ENLARGED), SHOWING THE NUCLEUS.

Experiments upon animals have shown that if a nerve going to any part is cut, the application of electricity to the outer portion of the nerve will cause the muscle to contract but will not cause any feeling; while if electricity is applied to the inner portion there will be no muscular contraction, but a feeling of pain. This experiment shows that nerve trunks are made up of two kinds of nerve fibers, one carrying impressions

inward to the brain, and the other carrying impulses or commands *outward* to the muscles, or other organs.

Ingoing and outgoing nerves.

The nerve fibers which carry impressions or sensations inwards are called sensory nerves, while those which carry commands or impulses outwards and cause all the different motions of the body, are called motor nerves. In the spinal nerves, the sensory and the motor fibers are generally bound together in the same bundle. Most of the cranial nerves are composed exclusively of either sensory or motor nerves.



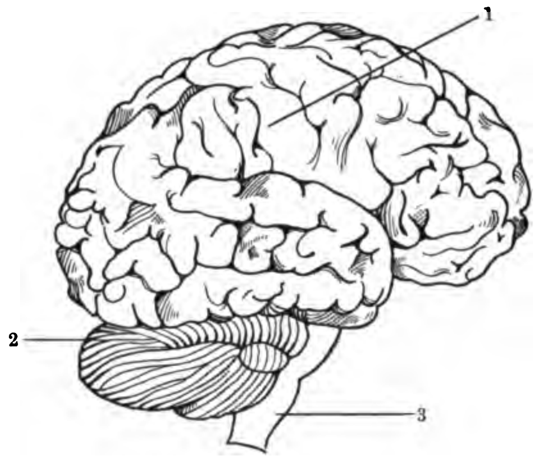
A SPINAL NERVE
1, posterior root; 2, posterior root ganglion; 3, anterior root.

Think of the different kinds of sensations which you experience and see how many you can enumerate. Besides the special senses, — hearing, seeing, smelling, tasting, and feeling, — we have what are called general sensations, such as fatigue, hunger, thirst. You will see that the sensory nerves are of many different kinds. For each kind of sensation, there is in the brain a special group of cells or a nerve center having charge of that particular sense, as you can see in the picture.

The motor nerves, or nerves of work, are also connected with different groups of cells in the brain, each

of which has charge of some particular organ or class of organs. The muscles, the stomach, the liver, the kidneys, and all other important organs have each their controlling centers.

It is not easy to comprehend the exact manner in which impressions are carried by the nerves. The best way, perhaps, is to compare the process roughly to the action which passes along a row of bricks set on end in such a way that when a brick falls over it will strike the one next to it, which in turn will fall against the next, and so on to the end of the line. No matter how great the length of the line, the impulse given to the first brick will be sent through all the bricks to the last. If we imagine the line of bricks to be a nerve fiber, with one end in the skin and another connected with a cell in the brain, we may get some idea of how an impression may be conducted along a nerve.



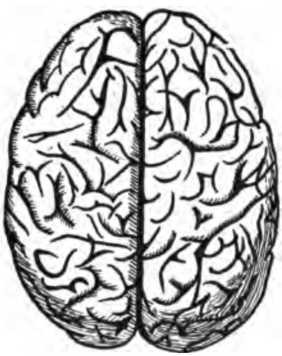
LOOKING AT THE RIGHT SIDE OF THE BRAIN.
1, cerebrum; 2, cerebellum; 3, medulla.

(1) The large mass of nerve tissue which fills the

upper part of the skull is called the cerebrum. It makes up three fourths of the entire brain and is sometimes called the large brain, to distinguish it from the cerebellum, which is sometimes called the small brain.

The brain parts and their work.

The cerebrum is divided into two hemispheres, the right and the left. The surface presents many furrows and folds, called convolutions. The outside is covered with layers of nerve cells, which give it a gray color. It is this gray matter of the brain with which one's mind is chiefly associated. Underneath the gray matter the brain is white in appearance and is composed of the nerve fibers which connect with the cells. A network of fibers connects the different parts of the cerebrum, and countless fibers pass into the spinal cord.



THERE ARE TWO HALVES TO THE BRAIN. YOU ARE LOOKING DOWN ON TOP OF THE BRAIN NOW.

The cerebrum is used in all our thinking. Through the nerve messages which come to it from all parts of the body, it receives the sensations of light, heat, sound, smell, taste, and others. It also sends out the messages that cause voluntary movement. Every part of the muscular system is connected with the brain; and each group of muscles has a corresponding group of cells by which it is controlled.

When the cerebrum is removed from the brain of an animal, it does not die at once, but a remarkable change takes place in it. If it be a frog, it will swim when placed in water, and hop when pinched or stimulated in any way. In this respect it appears like any other frog. But it seems to have no sense. It is, in fact, quite idiotic. If made to hop, it will hop into the fire as readily as anywhere. If left alone, it will remain without stirring until it perishes. It has no power to issue commands. It can perform only those reflex actions which require no intelligence but which are the response to some outside stimulus. Why can it perform such acts but not those requiring intelligence?

Disease of this part of the brain in human beings weakens the intelligence. It has been observed that the larger the cerebrum in proportion to the rest of the brain, the greater the intelligence of the animal. It is proportionately larger in man than in any other animal.

(2) Beneath the back part of the cerebrum is the cerebellum, or little brain. It is similar in form to the cerebrum, and like it is divided into a right and left half. It is also covered with a layer of nerve cells.

When the cerebellum is removed from birds or animals, they lose the power to make regular movements. A man whose cerebellum is injured staggers about as though intoxicated. The movements are

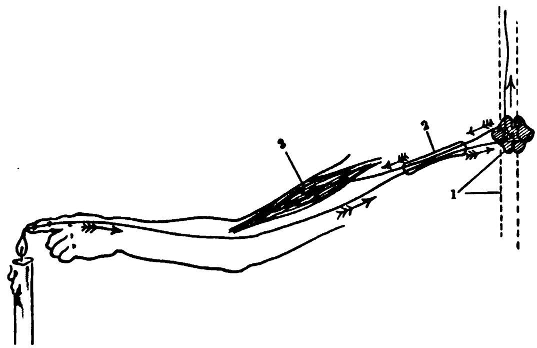
jerky and overdone. A person who is intoxicated can not walk steadily, because of the paralyzing effect which alcohol has upon the cerebellum. So it seems that the chief office of the cerebellum is to regulate and coördinate the movements of the muscles, and to keep a proper balance of the body by causing them to act in harmony.

(3) The medulla is an expansion of the upper end of the spinal cord. It contains many nerve fibers which connect the higher parts of the brain with the spinal cord and the body. It is a center for reflex and automatic actions, especially those which are of the greatest importance to the body, such as the beating of the heart and breathing.

We have seen that life may continue although the cerebrum or cerebellum are injured or even removed. But the mere puncture of the medulla with a needle is sufficient to cause death, because it stops the breathing. For this reason the medulla has been called the "vital knot."

(4) The work of the spinal cord is the same as that of the medulla. It is the passage through which impulses are conducted to and from the brain. It is also the center for reflex actions. If the spinal cord is cut across or severely injured, all parts of the body below the injury are paralyzed, and lose their feeling, because they have lost their connection with the cerebrum, the seat of feeling and of action. But reflex actions are still possible. For instance, a hot iron applied to the foot will produce no pain, even though

the foot may be severely burned. But if the sole of the foot is tickled, it will be jerked away by a strong contraction of the muscles, although the person may not even know that his foot has moved. The feet of a person who is sound asleep will move in the same manner when tickled. This shows clearly that the spinal cord without the aid of the brain can carry on reflex actions for those parts of the body that are supplied by the spinal nerves. For this reason a frog without a head may be made to hop, or a headless turtle to walk about. It does this by means of the spinal cord.



TRACE THE COURSE OF THE PAIN OF THE CANDLE TO THE SPINAL CORD (1), THEN THROUGH THE NERVE (2) TO THE MUSCLE (3).

When the hand comes in contact with a hot object, it is instantly drawn away. One does not have to say to oneself, "My hand is likely to be burned, so I had better draw it away." The hand is pulled away before there has been time for thought. In a little baby with no power to reason the hand would instantly be pulled away from a candle flame. When a sensation gives rise to motion in this way, the

Reflex action.

action is called reflex. Reflex actions are of immense importance in protecting the body from injuries of various sorts. The acts of winking, swallowing, sneezing, coughing, and vomiting are all reflex. These are helpful movements; and the impulse to perform them may be so violent that it cannot be suppressed by the will. Sneezing, for example, is for the purpose of discharging some offending object from the nose; coughing for removing some object from the air passages; vomiting to empty the stomach of something that needs to be got rid of. The closing of the eyelid when the eye is touched is another example of reflex action. The internal organs are controlled almost entirely by such action. Even during sleep, the reflexes, as they are called, are still active, drawing up the foot when the sole is lightly touched or pulling away the hand if pricked.

Besides these natural reflex actions requiring no intelligence, there are what are called acquired reflexes.

Acquired reflexes. Take the act of walking, for example. When a child first attempts to walk, a voluntary effort is required each time the foot is moved and put forward. After a while he can walk a long distance without thinking about it or giving any attention to the feet. The mind may be wholly occupied with something else. The action has then become reflex; it does itself without any effort of the mind. This is true only when one walks at his usual pace. If you try to walk much slower or much faster than usual,

you will find that you have to make a constant effort to do so.

Writing is at first a laborious act, which requires very close and constant effort to direct the muscles employed. But the accomplished penman is able to write rapidly without seeming to give any thought to the formation of the letters. He thinks of the word he wishes to write and his hand produces it. In swimming, bicycle riding, piano playing, and many other performances, the necessary movements are made without thought, after the nerves involved in them have been trained by practice. Without this arrangement it would not be possible to become very skillful in any art or trade.

At the base of the large brain or cerebrum are some very interesting groups of cells which serve as middlemen. They receive orders from the large brain and transmit them through the spinal cord to the organs for which they are intended. Acts which are performed very frequently are for the most part passed over by the cerebrum to these centers. They may be called the servants of the cerebrum, since they are always in waiting to carry out its orders and at last become so well trained that they can do some kinds of work without supervision of the higher centers. In this way the cerebrum is relieved from much labor and drudgery and left free for higher kinds of work.

Each time an act is repeated it is done with a little greater ease. After a time it is done without any

effort of the mind. Then it has become a habit. "Sow an act and reap a habit; sow a habit and reap a character." Every act of importance not only originates in the brain, but it makes an impression upon it. It is in this way that our characters are built. The character is largely formed by our habits. Perhaps we may say that our character is the sum of all our habits, and our habits are formed by constantly repeated actions.

How habits are formed.

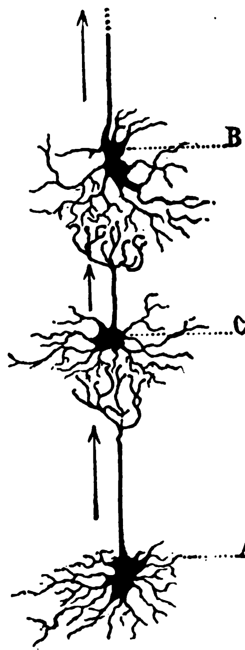
One of the most wonderful of the abilities of the mind is memory. How are sight pictures and sound pictures stored in the mind, and how are we able to recall them? In some way impressions made through the eye, the ear, and the other senses cause such actions and changes in the nerve cells that they are able under the right sort of conditions to call back the impressions they have received.

How we remember.

By means of the delicate nerve branches sent out by the cells, the cerebrum, the seat of the mind, is connected with other parts of the brain in which impressions are stored. The nerve cells are able to stretch out or draw back their branches, thus making or breaking the contact with other cells. The effort to recall anything is simply an act of the will, stimulating the nerve cells and causing them to stretch out their branches in various directions. The moment the right contact is made, the desired fact or picture will flash into the mind. When we are weary we find it often difficult to recall things with which we are quite familiar.

It seems that then the nerve cells can not make the desired contacts with other groups of cells.

In order for a thing to be remembered it is necessary that *the first impression shall be clear and strong*. Whether an impression lasts or not depends mainly upon how clear it is. For this it is necessary that *the attention should be concentrated* while the thing is being learned. Good attention is the first essential of a good memory. The more active the mind is in regard to any impression when it is being made, the longer it is likely to be retained.



THE BRANCHES OF THE NERVE CELLS *B* AND *C* ARE STRETCHED OUT TO RECEIVE A MESSAGE COMING FROM THE CELL *A*.

How to have a clear head.

Exercise is quite as necessary for the health of the brain and nerves as for the rest of the body. Mental strength and capacity are developed by mental work, just as the muscles are developed by muscular work. So, too, the brain may be injured by overstudy, just as may the muscles be hurt by overstrain.

When the brain is weary, impressions made upon it are slight and soon become indistinct. For this reason it is not best to spend more than two or three hours at a

time in hard study without rest. A short period of exercise, especially if taken in the open air, will refresh the brain and make it active and ready to receive new impressions.

Muscular exercise is of great benefit to brain workers. We have seen how exercise keeps the stream of life fresh and pure and washes away the poisonous products that tend to clog the mental machinery. Students and professional men break down much more often through neglecting to take muscular exercise than through doing too much mental work.

Plenty of fresh air and good food are needed for the support of the brain and nerves, just as for the rest of the body. Eating too much or living on unwholesome or indigestible food clogs and hinders the brain in its work. Clear thinking and a good memory can go on only in a healthy and unclouded brain. Overeating and indigestion are especially likely to weaken the memory and to produce a state of mental confusion, lack of power to concentrate the mind, and inability to decide questions.

Do you think an abundance of sound sleep is necessary for the health of the nervous system? Why? During perfectly sound sleep, the brain is wholly inactive. The blood is drawn away to other parts of the body, the spaces about the nerve cells are filled with lymph, and the parts worn by use undergo repair. During the activity of the day there is little opportunity for the repair of brain tissue. This work is done almost

wholly during sleep. It is then that the cells of the brain and other nerve centers accumulate a new store of energy. At least seven or eight hours of sleep are required daily. Children and young persons require more than older persons.

During unsound sleep the brain is partly active but in an irregular way. Confused pictures present themselves. The result is dreaming. When one constantly dreams at night of the work he has been doing, it is an indication that those parts of the brain used during the day are not being properly rested and restored at night. They are in danger of becoming diseased. A vacation or change of occupation is then necessary. Sleeplessness is often caused by eating late in the evening. To secure sound sleep it is best to take only ripe fruit or other very easily digested food for the evening meal. Tea, coffee, and chocolate produce sleeplessness.

Fatigue produced by exercise out-of-doors has a wonderful effect in causing sleep. A prolonged bath, from fifteen to twenty minutes, at a temperature of 92 to 95 degrees, taken just before going to bed, is an excellent remedy for sleeplessness.

Nerve poisons.

We have already seen the effect of alcohol in paralyzing the nerve cells that control the movements and so causing a staggering walk and falling. Alcohol also makes a man temporarily insane, by paralyzing certain of the nerve cells so that the brain is unable to make correct judgments. Peculiar and unnatural combinations of ideas are made, often with

terrible results. A man who is naturally peaceable may while under the influence of alcohol become violent, destructive, and ferocious. In the disease caused by alcohol, called delirium tremens, the drunkard's ideas become curiously mixed. The sufferer sees snakes, reptiles, and all sorts of monsters and strange shapes before him.

The ill effects of tobacco upon the nervous system have been pointed out by many eminent physicians. Here are some of the things they say about it: —

"Giddiness is a common effect of excessive tobacco smoking. Tremor is one of the commonest. It may be got rid of entirely by leaving off the tobacco."

"Sleeplessness is one of the most common effects of tobacco smoking."

It has been shown that tobacco poison affects the auditory nerve and so causes defective hearing or deafness.

"The use of cigarettes has an evil effect upon the mucous membrane lining of nose and throat, and as these organs are closely connected with the organ of hearing, anything that affects them is likely to react upon the hearing."

Tobacco also affects the optic nerve and so blunts the power of color perception and affects the sight in other ways. This is recognized in every trade or profession that requires quick and accurate sight.

A certain railway company issued the following notice to employees: "*For the betterment of the service*

and *the safety of the public* it will from this date be the policy of this company NOT to retain in its employ men who use intoxicating liquors or cigarettes."

Tobacco has also a most marked effect upon the mind, especially of young smokers. Out of 2,336 cigarette smokers who were attending public school, only six were reported as "bright students." A very few were "average." All the rest were "poor" or "worthless" students.

Its effects upon the moral nature are even more marked. A physician who has had the best opportunities for seeing the effects of tobacco upon the morals says: "I speak from a personal knowledge of scientific truth. The smoke is inhaled into the lungs, the poisonous gases are communicated through the blood to the brain and to the nerve centers that control the moral sensibilities, stupefying and destroying. Soon the fine edge of the moral nature is blunted, and the difference between right and wrong is blurred."

A physician in an institution for the insane says: "I know whereof I speak when I say that tobacco, when habitually used by the young, leads to a species of imbecility; that the juvenile smoker will lie, cheat, and steal, things he would not do had he let tobacco alone."

Health Problems

1. Suppose you should cut a nerve leading to the end of your finger and you could keep it from healing. What would happen

to your finger? Why? If you should cut through the nerves on one side of your finger and they should not heal, would it mean that you would lose the part of the finger below the cut? Explain.

2. Does nature take special pains to keep the brain from becoming injured? If you think so, give reasons.

3. Why does man, like most other animals, have such a long spinal column? Why did not Nature try to get along without a spinal column?

4. Show just how a command gets from your brain down to the last joint in your finger, so that you can move it. How does a command travel down to your big toe so that you can move it?

5. What is the meaning of the word sensory? What is the meaning of the term motor? Distinguish accurately between the two.

6. Show whether the word cranial is a good term for the nerves to which it is applied. In the same way, show that the term spinal is a good term for the nerves to which it is applied.

7. Suppose there were no groups of cells in the brain that attended to special work or controlled special organs; do you think a man could then receive as many impressions and do as many things as most men can?

8. Think of a good way to show that there is a special group of cells in the brain that has to do with vision; another group that has to do with hearing; another group that controls the right hand, and so on. How do you think people have discovered that there are special groups of cells in the brain?

9. Mention a number of reflex actions which are not spoken of in the text. Are all the reflex actions you can mention useful to the person in whom they occur? Can you mention any harmful reflex actions? If so, how would you control them so that they would not get one into trouble?

10. Mention some reflexes which you have acquired.

11. Mention at least five habits you possess which are not

mentioned in the text. Why is it proper to speak of one's character as "the sum of his habits"?

12. Can you close your eyes and see how your father, mother, brothers, and sisters, look? Can you get an image of your breakfast table, so that you can describe the dishes, the people who sat around the table, and so on?

13. Can you now hear the voices of your father and mother, brothers, and sisters even though they are absent?

14. What things that happened last Fourth of July do you remember clearly? Explain why you have not forgotten them.

15. Take something you have forgotten in literature, arithmetic, spelling, or any other subject, and see if you can tell why you have not remembered it. What could you have done so that it would have remained with you?

16. Have you ever tried taking exercise when you could not learn rapidly? Has it cleared up your mind? If you are tired and take exercise, will it help you in your study? Explain.

17. What has happened in the nervous system of the person who is drunk? Suppose the alcohol remained in his system continuously, what would become of him?

18. Why does a person who is learning to smoke have headaches, vomiting, and other disturbance? What do these disturbances show with regard to Nature's plan?

Review Questions

1. Where do the commands come from that set the digestive organs at work, that make the lungs work faster when necessary, and so on?

2. What are the two kinds of nervous tissue?

3. Describe the nerve cell. For what use are the buds on the branches of nerve cells?

4. What is a nerve center, or ganglion?

5. What are the bundles of nerve fibers called?

6. What are the two divisions of the nervous system?

7. What is the "headquarters," as one might say, of the nervous system?

8. How does the spinal cord connect with the brain? Describe this cord in detail alone, and in connection with the rest of the nervous system.

9. For what are the nerves used?

10. Of what is the matter in the center of the cell composed?

11. What are the nerves that convey impressions from the senses to the brain called? What, those that carry commands from the brain to the muscles?

12. What are the general sensations which the brain receives? What are the special sensations?

13. Show how impressions are conducted from nerves to the brain or from the brain to the muscles.

14. What is a reflex action? What is its use? Name some reflex actions which may occur during sleep.

15. What name is given to the large brain? What name is given to the small brain?

16. With what is the outside of the brain covered? What is its color?

17. What part of the brain do we use in our thinking? Where is this part located?

18. What happens to a frog when its cerebrum is removed? What does this show regarding the work of the cerebrum?

19. When the cerebellum is removed from birds and animals, what happens to them?

20. Where is the medulla situated? What work does it have to perform?

21. What is the work of the spinal cord?

22. Why can reflex actions occur when a person cannot feel anything?

23. How is it possible for a frog without a head to hop?

24. What is the office of the "middle men"? Give some examples.

25. How does one form habits? What is the relation between habits and character?

26. How is it possible for one to retain the memory of any experience he has had?

27. Why is it difficult to recall things when one is weary?

28. What is necessary in order that one should be able to remember anything? How could one cultivate a good memory?

29. Is exercise necessary for the health of the brain and nerves? Why?

30. How can one develop mental strength and capacity?

31. Why is it not best to study when one is fatigued? What kind of exercise is good for brain workers? Why?

32. What sort of habits will interfere with one's having a clear head?

33. Is sleep necessary for the health of the nervous system? Why? What is a good way to overcome sleeplessness?

34. Why does one dream? What kind of habits will be likely to make one dream a good deal?

35. Mention some nerve poisons and their effect on the brain and nerves.

36. What do physicians say about the effect of tobacco on the nervous system?

CHAPTER XIII

Gateways of the Mind — Sight

The brain has only one way of getting information from the outside world. This is by means of sensations received through the nervous system. There are two kinds of sensations: (1) Those which arise from conditions within the body, such as fatigue, drowsiness, pain, hunger, and thirst. These are called general sensations. (2) Those which are caused by some stimulus from outside, — sight, hearing, smell, taste, and touch, by means of which we get a knowledge of objects in the world about us. These are called the special sensations.

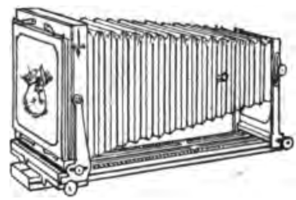
The special senses are the avenues or gateways to the mind. The information brought to the brain through them is the food of the mind, or thought material.

Perhaps the most remarkable of these avenues to the brain is the eye. The eye is a picture-making instrument, very much like a photographer's camera, only much more wonderfully and perfectly made. The eye of an ox recently killed may be prepared in such a way that one can clearly see the picture formed by the lens of the eye on the dark curtain stretched across the back of the eye globe. In some

The eye the body's camera.

mysterious way, by means of the special nerve, the optic nerve, which connects the eye with the brain, a record is made of this picture in the cells of the brain.

Ingenious human inventors have labored for many years to solve the problem of the sending of a picture over a telegraph wire. Here we have the thing done, apparently only a bundle of minute white threads running from the brain to the eye, spread out in a thin, transparent membrane over the screen upon which the picture is formed.



THE EYE IS A PICTURE-MAKING INSTRUMENT, SOMETHING LIKE A PHOTOGRAPHER'S CAMERA.

One looks at an object: the face of a friend, a beautiful flower, a strange animal, a collision of vehicles in the street. The next day, or it may be years after, the picture may be reproduced in the mind, showing that a record has been made in the brain. A famous artist once produced from memory a copy of a picture hanging in a gallery in a distant city. The copy was so like the original that it was difficult to distinguish it from it. This is what the brain is doing all the time for every one who has a healthy brain and eye and optic nerve.

The picture in the eye, instead of being painted there, as in a photograph, is bleached there by destruction of the coloring matter on the screen where the rays are focused. This produces a picture in white. A chalk

picture made upon a blackboard must be wiped off before a new picture can be drawn there. Otherwise the lines would be mixed and the pictures indistinct. For this reason the eye picture must also be effaced before a new picture is formed. This is done by a constant reproduction of the coloring matter to prepare a new screen for every new picture. So rapidly is this work done that it is possible for one to form a clear, distinct picture of a new and separate object eight times in a second.

The eye is well protected by nature. The eyes are set in deep bony sockets in the skull, open in front.

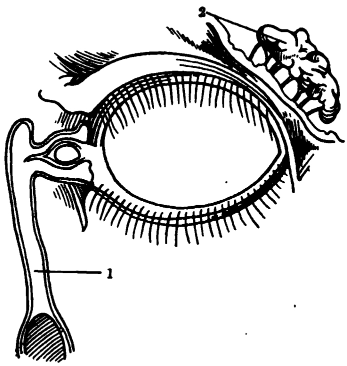
The protection of the eye.

At the back part there is an opening through which pass the nerves which connect the eye with the brain. The eye socket is lined with fat, which forms a soft cushion for the eye to rest and turn on, and it helps to protect the eye from injury.

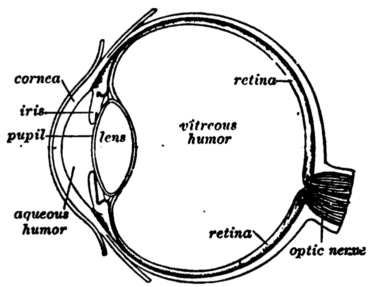
The eyelids, eyelashes, and eyebrows also assist in protecting the eyes from injury. The eyelids protect the eye from too much light and close down and cover the exposed part of the eyeball if a blow or other injury is threatened. Along the edge of the folds of skin that form the eyelids may be seen the openings of numerous little glands which pour out an oily substance that prevents the overflow of the tears. The eyelashes, with which the edge of the lids is also furnished, keep dust out of the eyes.

The little gland that produces the tears, the lachrymal gland, is within the socket of the eye, at the outer and

upper side. A secretion is constantly being formed in small quantities for the purpose of moistening the eyes. This secretion is drained away by means of two little canals, one at the edge of each lid, at the inner corner of the eye. These little canals open into a small sac from which the tears are carried into the nose, through a duct called the nasal duct. When the secretion from the lachrymal gland is formed in too great quantity to be carried off in this way, the tears flow over the lids and run down the cheeks.



WHERE THE TEARS ARE MADE, AND HOW THEY ARE DRAINED OFF.
1, the nasal duct; 2, the lachrymal gland.



THE PARTS OF THE EYE.

The parts of the eye and their uses.

Each eye is provided with six little muscles. One end of these is attached to the socket and the other to the eyeball. By this means the eye may be turned in various directions. Think what would be the effect it if were not possible to move the eyeball!

The eyeball has three layers or coats: the outer

coat, or sclerotic; the middle coat, or choroid; the inner coat, or retina.

The sclerotic is formed by a dense white membrane, — the white of the eye, as we call it. In the front of it is a transparent portion called the cornea, which lets the light through into the eye, just as a window lets the light into a room.

Next to the sclerotic and in close contact with it is the choroid, which is of a rich, purple color. In the front of the choroid, just at the back of the transparent cornea, is the iris, a movable, muscular curtain lined with dark pigment. The iris is the colored part of the eye, blue, brown, gray, or black, which we see through the transparent cornea. It has in the center an opening which we call the pupil.

The iris regulates the amount of light that enters the eye. When the light is dim, the opening is enlarged to let in as much light as possible. When the light is strong, the pupil is made very small to protect the eye. You have seen the pupils in the eyes of a cat in the sunlight reduced to mere slits, while in one that has been in the dark the pupils are so enlarged that the iris can scarcely be seen. The pupils of the eyes of cats and some other animals can be opened wider than the human eye, so that they can see at night better than we can.

The retina, the inner coat of the eyeball, contains the nerves of sight. It is formed by the spreading out of the optic nerve, which enters the eyeball at the back,

nearly opposite the pupil. It is composed of several layers of different kinds of cells, which are connected with the ends of the fibers of the optic nerve. In this way it is connected with the nerve centers in the brain that preside over the sense of sight. The layer of cells next to the choroid or middle coat has a purple color. The color fades when the retina is exposed to light, but is constantly reproduced by the choroid.

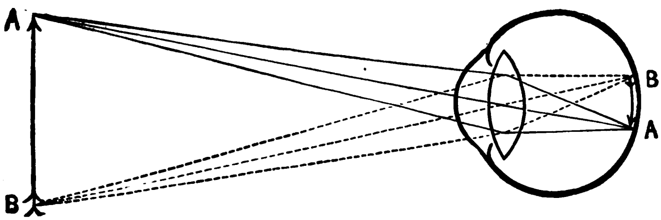
Just at the back of the iris is the crystalline lens, which divides the inside of the eye into two chambers. The large posterior chamber at the back of the lens forms the greater part of the cavity of the eyeball. It is filled by a transparent, jellylike substance called the vitreous humor. The small anterior chamber in the front of the lens is filled with the aqueous humor, a watery fluid which runs out when the eyeball is pierced with a sharp instrument.

The way we form images and retain them.

The lens, aided by the convex surface of the cornea, forms images of the objects that we see. An image formed by a lens in the front of a camera may be seen upon the ground glass at the back of the camera. If we hold a convex lens before a window and at the proper distance from a screen of thin oiled paper or ground glass, we may see upon the screen a perfect picture of the window, but much smaller than the original. The lens and the cornea of the eye form images upon the retina in the same way that the image is formed on the screen or camera.

Many colored fabrics fade or lose their color when long exposed to the sun's rays. Muslin may be bleached or made white by exposure to the sun. When the retina taken from the eye of an animal is exposed to the sun the color is bleached out in the same way. But if it is left in contact with the choroid, and is placed in the dark, it will soon recover its color.

If we allow the image formed by a lens to fall upon the retina taken from the eye of an animal, the picture will be bleached upon the retina by the action of the



THE FORMATION OF AN IMAGE ON THE RETINA.

sun's rays. This is exactly what happens when we see an object. The lens of the eye, assisted by the cornea, forms upon the retina an image which is bleached out in the way described. The impression made upon the retina is carried to the brain by means of the optic nerve.

Impressions made upon the retina may last after the object making the impression is removed. A thing may be looked at for only the hundredth part of a second, yet it will take a whole tenth of a second for the image formed to die away. You can see that if a second

picture is presented before the first has died away, the pictures will blend. The effect is then the same as if both objects were seen at the same time.

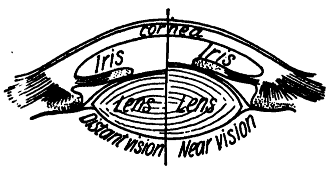
A toy has been made to illustrate this. It consists of a piece of white card with two strings upon which it can be twirled. On each side of the card a different picture is painted. Suppose, for instance, that on one side of the card is a lion and on the other his cage. When the card is rapidly twirled by being blown upon, the lion will be seen in his cage. Or it may be a horse on one side and his rider on the other. Twirling the card rapidly will have the effect of seating the rider upon his horse. Explain the principle.

If you examine carefully the image made by a lens you will see that the picture is inverted, or bottom part up. The two sides are also reversed. This is because the rays of light cross each other in passing through a lens. Why is it that though the picture in the eye is upside down, yet we seem to see the object right side up? Do you think the infant sees things right side up as we do?

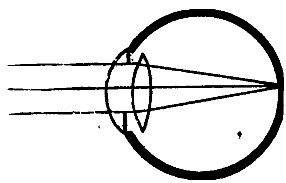
Seeing near and far objects.

By experimenting with a lens held at a certain distance from a screen, you will see that the images of near and of distant objects are not equally perfect. In order to get good pictures of all objects, you must either change the position of the lens, or use a thicker lens for near objects and a thinner one for distant objects. The position of the lens in the eye can not be changed. It is fixed at a

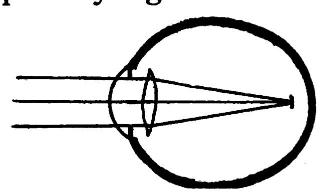
certain distance from the retina. Neither can it be exchanged for a thicker or thinner one, according to the object to be looked at. But nature has provided a means by which the lens may be made thicker or thinner and so adjust itself perfectly to see objects at different distances. This is done by means of the muscular ring surrounding the lens, — the suspensory ligament. This work of adjusting the lens is called accommodation. The eye seems to see without effort objects at a distance, and accommodation is exercised only for near objects. A perfectly natural eye can not adjust itself to see objects nearer than five to eight inches.



SHOWING CHANGES IN THE LENS IN ACCOMMODATION.


AN EYEBALL OF JUST THE RIGHT LENGTH.

In reading or in doing any kind of work held near the eyes, the muscles of the suspensory ligament are contracted to thicken the lens and so adjust it for seeing near objects. If the work is long continued, these muscles may become wearied. It is a good thing to relax these muscles and rest the eyes by gazing out of a window into the distance.

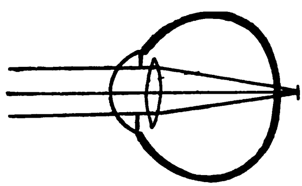

A LONG EYEBALL.

In some persons the eyes are long from the front to

the back, so that the retina is farther than usual from the lens. Here is a little experiment which will help you to understand what effect this has upon the sight.

Two kinds of sight.

Take a lens which will make a distinct image of distant objects upon a screen held a few inches behind it. If the screen be moved a little farther from the lens, the image of distant objects will become indistinct. But if an object is held near the lens, a clear image of it will be formed upon the screen. This shows us that if the retina of an eye should happen to be farther from the lens than it ought to be, distant objects would not be seen clearly, although near objects might be seen distinctly, even nearer than by the ordinary eye. A person having such eyes is said to be short sighted.



A SHORT EYEBALL.

In other cases the eyeball is shorter than usual, so that the retina is brought too near the lens. In these cases distant objects may be clearly seen, while near objects are blurred or indistinct. Such eyes are called long or far sighted.

If you watch an elderly person trying to read without glasses, you will notice that usually the book is held a long way from the eyes. The reason for this is that at about the age of forty-five years the lens begins to harden, so that it can not be accurately adjusted to near objects.

In some cases the curvature of the cornea is uneven and some parts are flatter than other parts. When this irregularity is enough to distort the image so that objects are not seen clearly, it is called astigmatism.

Near-sighted, long-sighted, and old persons need the assistance of glasses which will cause the image to fall exactly on the retina, and so be distinctly seen.

Wearing glasses.

For a near-sighted eye, in which the rays of light meet before they reach the retina, concave lenses are needed to spread the rays of light farther apart. Far-sighted eyes, in which the rays reach the retina before they meet, need convex lenses, which will bend the rays of light toward each other, and cause them to meet more quickly. Old persons need convex lenses which should be changed as age increases. When an old person finds himself obliged to pull his glasses down on his nose in order to see clearly, it is a sign that he needs a stronger pair of glasses.

With what do we really see?

The eye is the organ of sight, but it is with the brain that we actually see. If the optic nerve is cut, pictures will still be formed in the eye but there will be no sight. It is with the brain that we form judgments of the images transmitted through the eye, as to their distance, shape, position, solidity. The nerve centers controlling sight have to be trained by practice to form accurate judgments. A little baby reaches out for everything it sees, no matter how far away, and experiments have shown that it is months before it has a definite idea of distance. Why?

A young Scotchman who was born blind received his sight by means of an operation when he was thirty years old. He at first thought that everything he saw was quite close to him. The first day that he sat at the window, he put out his hand to touch the sidewalk, which was two stories below. He said, "The first meal I ate was an odd experience. When I saw that great hand with a huge fork approaching my mouth, the impulse to dodge was almost irresistible." Explain this man's experience.

The care of the eyes.

The eyes are such a precious possession that they need to be guarded carefully. Think from how much one is shut out who does not have the use of these wonderful organs that tell him of all the beautiful and interesting things in the world around him. Carelessness in the use of the eyes while one is young may cause a great deal of trouble and even blindness later in life.

It is of importance that the eyes should not be strained. This is most likely to occur in reading. When one is interested in a book, it is sometimes a temptation to go on reading into the twilight, before the lamps are lighted. Reading in a poor light is a great strain on the eyesight. Why? Reading very fine print for a long time without resting the eyes also strains them. Why?

Reading on the cars is likely to be injurious to the eye, because of the shaking which continually changes the distance between the book and the eye. You can

see what a tax this is upon the muscles of accommodation, which must keep adjusting the eye to the changed distance.

Reading while lying down is a bad practice. In this position too much blood comes to the eyes, which are likely to become congested. The book is also likely to

Some people have the bad habit of reading in bed.

be held in an awkward position which may strain the eyes.

It is not a good thing to read when first awaking in the morning, as it takes a little while for the eyes to become accustomed to the light. Sudden exposure of the eyes to very bright light may be injurious for the same reason.

The direction in which the light falls is of very great

importance to the eyes in such occupations as reading, writing, and needlework. The light should shine upon the work, not upon the eyes. You may find out for yourself the best position for doing near work of any kind by trying a few experiments. Sit or stand with your back to a window while you read. You will see that

THIS BOY'S EYES WILL BE HURT IF HE DOES NOT KEEP THE BRIGHT LIGHT FROM SHINING DIRECTLY INTO THEM.

your shadow falls upon the page and darkens it. Now face the window, and you will see that this is even more unsatisfactory. The light shines directly into the eyes, while the book is in shadow. Standing with your right side to the window you will find a great improvement. The light now falls directly upon the

page and not upon the eyes. But try writing in this position. The hand then casts a shadow upon the paper which will obscure the light just where it is most needed. Stand now with your left side to the window, and you will find that the light is just right for all purposes.

Notice where the windows in your schoolroom are

WHICH OF THESE THREE CHILDREN HAS THE BEST POSITION FOR THE EYES? WHICH THE WORST POSITION?

placed and how the light falls upon your desk. Is it a good thing for the teacher's desk to be placed in front of a window? Which is the best position for the blackboards, between the windows or facing them?

Severe headaches, indigestion, and other nervous troubles may be caused by defective eyesight. If the eyes become easily tired and can be used but a short

time without blurring of the vision or aching of the eyeballs, they should be examined by a specialist, and if possible, properly fitted with glasses. It has been found that from 30 to 60 out of every 100 children in the public schools should wear glasses.

The corners of the eyes should be kept clean, and the lids washed carefully. A disease which causes very great soreness and inflammation of the lids is due to the growing of germs inside the lining of the eyelids. It is not safe to use public wash basins or towels, because of the danger of getting the eyes infected with these germs. Children suffering from this disease are not allowed to attend the public schools, because of the danger of infecting other children.

At home as well as at school and wherever the person is who has a communicable eye disease, the greatest of care should be taken that its germs are not scattered.

To rub the sore eyes with the hands is sure to get germs on them. If before washing the hands, the patient handles books, toys, or any similar thing, some of the germs are likely to be left on these articles. Other persons using these things get germs on their hands. If then one such rubs his own eyes with unwashed hands, the circuit from the diseased eyes to well ones will be completed and the seed planted for another case of eye trouble. One can hardly expect to keep germs from getting on the hands, since whatever large numbers of people handle, such as door knobs, stair railings, car straps, library and school books, are likely

to carry them. But one can prevent their being introduced into the eyes, if he heeds this most important rule: *Never rub the eyes with unwashed hands.*

The careful provision made by nature to protect the eyes from dust is enough to point out to us the fact that dust is very injurious to the eyes. It irritates the lining of the eyelids, scratches the surface of the eye and may carry into it the germs that cause inflammation. If a speck of dust, a cinder, or some substance gets into the eye, *do not rub it*, as this may cause the particle to become embedded in the lining or in the surface of the eye. Carefully draw the upper lid over the lower. In many cases this will remove the particle. Or holding up the eyelid and moving the eye about may remove it. It may sometimes be washed out by bathing the eye.

Health Problems

1. Can you give any estimate of the number of pictures that are recorded in your brain? Do you think all the objects you have ever seen have left images in your brain? Why?

2. What do you think is the reason that the nose has been made so prominent, while the eyes have been set back in sockets?

3. See if you can count all the different movements that can be made by the eye. Is each movement of service to us? How? How are we able to execute all these movements?

4. Make a drawing which will show what a concave shape is. One that will show a convex shape. What is a good device to distinguish between a convex and a concave shape?

5. Suppose one should lose the choroid coat of the eye. What would happen to his sight?

6. Can you suggest a good test besides the one mentioned in the

text to show that an image lasts after the object from which it is gained is removed? Hold the pages of this book before a mirror. What do you notice regarding inversion and reversal of images? Why is not the same thing true of our features when we look at them in a mirror?

7. How near can you put a small object to the eye and see it? Why can not you see it when it is brought nearer? Most old people wear what is known as bifocal lenses; that is, one part of the lens is a little differently shaped from the other part. One part is used for reading and all other near work, another part for looking at objects farther away. Why do not young people have to wear glasses like this?

8. Why is the lens of the eye thickened when one looks at near objects? Show by a drawing.

9. Show by a drawing why concave lenses are worn by near-sighted people, and convex lenses by far-sighted people.

10. Suggest an experiment which will illustrate ways in which many people fatigue their eyes.

11. How many pupils in your school wear glasses? How many of them have had their eyes tested by some man who knew just how to do it?

Review Questions

1. From where do our general sensations come? Mention some general sensations.

2. Whence come our special sensations? Mention some of them.

3. Why is it proper to speak of the senses as the gateways of the mind?

4. Which is the most remarkable of the gateways of the mind?

5. How do impressions get from the back of the eye globe to the brain?

6. How do we know that a record is made in the brain when we look at an object?

7. How are pictures made on the retina? What is meant by a photograph's being bleached on the retina?

8. How do the eyelids, eyelashes, and eyebrows help to protect the eye from injury?

9. What is Nature's provision for preventing the overflow of tears? How are the tears drained away?

10. What is the name of the gland in which the tears are formed? Where is it situated?

11. How many muscles are provided for each eye? How are these attached to the eye?

12. What is the outer coat of the eye called? The middle coat? The inner coat?

13. How is the sclerotic formed?

14. What is the cornea? Where is it located, and what is its work?

15. Where is the choroid situated? What work does it have to do? Where is the iris, and what is its work?

16. Where is the pupil of the eye?

17. Where is the crystalline lens, and what is its office in the eye?

18. Where is the vitreous humor?

19. Where is the aqueous humor?

20. What is the meaning of the convex lens?

21. Describe the toy which is designed to show that an image of an object lasts a little time after the object disappears.

22. Why is it that an image made by an object is inverted and the sides reversed?

23. What happens to the image when the distance of an object one is looking at is changed?

24. What happens to the lens when the amount of light entering the eye is increased or decreased?

25. How is it possible for the lens to become thicker or thinner?

26. What sort of work may fatigue the muscles controlling the lens?

27. Why is it that some people have short sight? Why is it that some people have far or long sight?

28. What kind of lens must a near-sighted person wear? What sort, a far-sighted person?

29. With what do we really see objects after all?

30. Describe the care that should be taken of the eyes in reading.

31. From what side should the light fall upon any work we are doing?

32. What troubles are likely to come from defective eyesight?

33. What care should be taken to protect the eyes from dust and the like?

CHAPTER XIV

Gateways of the Mind — Hearing

Each special sense organ gives us peculiar sensations which can not be given by any other organ. The eye gives sensations of light, and the ear sensations of sound. We have seen that sensations are caused by something in the world about us acting on some one of the sense organs. Now a little experiment will help to make clear to us what it is that gives the sensation of sound. Rest one end of a board upon a table, holding it in position with the left hand. Then draw a pin across the board with the right hand, and you will notice that the board trembles or vibrates. If you now press the head against the upper end of the board and draw the pin across it again, a loud sound will be heard. The vibrations of the board will be communicated through the ear to the nerves of hearing. We can hear the scratching of the pin, even though we do not place the ear against the board, because the vibrations of the board start vibrations in the surrounding air and these sound waves are brought to the ear. When the string of a violin or harp is made to "sound," you can see that it is in rapid vibration, and the same thing takes place in all sounding bodies.

You can get some idea of how sound travels by another simple experiment. Throw a stone into the calm water of a pond. You will see that a little ring of waves forms itself at the point where the stone struck the water, and these waves travel in all directions, as far as the water extends. If a piece of wood is made to float upon the water, it will bob up and down as the wave reaches it, being set in motion by the movement that was started in the water by the stone. Sound waves are made in the air by the vibration of sounding bodies in somewhat the same way as the waves are made in the water by the falling stone. These sound waves traveling through the air reach the inner ear and set its movable parts in motion, as the wave in the water sets the piece of wood in motion when it reaches it.

How we hear.

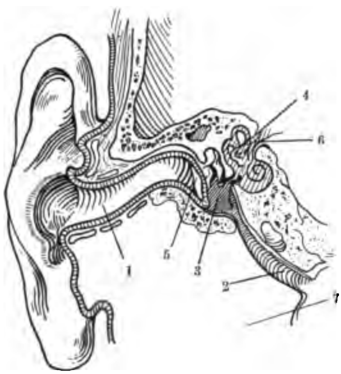
We see, then, that sound is the impression produced on us when the vibrations of the air strike on the drum of the ear. When the vibrations are few, the sound is deep and low; and when they increase in number it becomes shriller and higher. The lowest sound that can be heard by the human ear is made by about sixteen vibrations in a second. When the number reaches 40,000 in a second, the sound can not be heard by the human ear.

Think what a great variety of air movements there must be in order to cause all the kinds of noises we hear and the musical notes covering about a dozen octaves. Yet all these can be received by the ear and sent to the brain; and each keeps its own peculiar quality. So

sensitive is the ear that we can at once recognize a familiar voice, even though we do not see the face of the speaker. Let us take a look inside the ear and examine the wonderful mechanism by which this is done.

The parts of the ear.

(1) What is called the outer ear is (*a*) the part that we can see, and that we commonly speak of as "the ear," and (*b*) the auditory canal or tube through which the vibrations pass to the drum. The ear that we see seems to be placed where it is for the purpose of gathering up sound waves. You will often see a person who is a little deaf placing the hand behind the ear, and bringing it forward to assist the hearing. Ear trumpets are also used for this purpose. The drum is a membrane (the tympanic membrane) stretched across the lower end of the canal. It vibrates like the head of a drum when the sound waves strike upon it. Glands along the canal secrete the wax which guards the entrance to the drum.



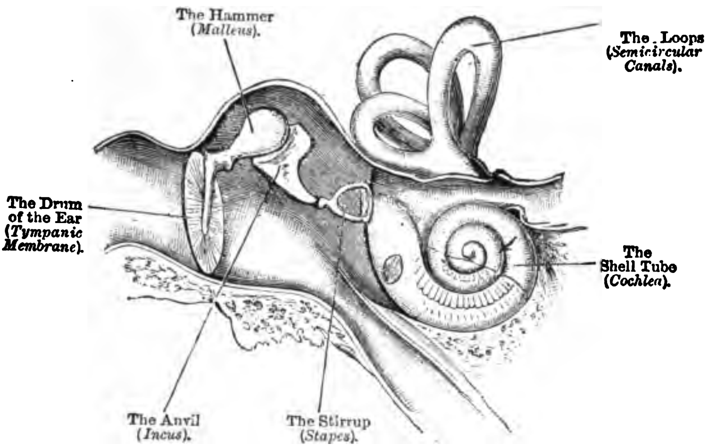
THE WONDERFUL MECHANISM OF THE EAR.

1, external auditory canal; 2, eustachian tube; 3, middle ear; 4, internal ear; 5, tympanic membrane; 6, auditory nerve; 7, pharynx.

(2) The middle ear, or drum cavity, is connected with the throat or pharynx by a small canal called the eustachian tube. The object of this tube is to allow a

change of air in the drum cavity so as to keep it at about the same density or pressure as the air outside. Otherwise the tympanic membrane might be bulged inward or outward by the unequal pressure on its two sides.

The air in the ear may be changed in the following manner: Grasp the nostrils between the thumb and



ALL THESE DEVICES ARE NECESSARY IN ORDER THAT WE MAY GET SENSATIONS OF SOUND.

finger, take a full breath through the nose, holding it tightly closed. As the air can not pass out through the usual channel, the nostrils, it is forced up through the eustachian tube to the middle ear. It cannot pass through the ear, unless the drum membrane has been torn. When an opening has been made in the membrane, a whistling sound may be heard when the ears

are inflated in this way. This inflation of the ears should not be repeated very frequently, but it may sometimes give relief and restore the hearing when the ears are "stuffed up" by a cold.

Passing across the middle ear, from its outer to its inner side, is a chain of three very small bones (the hammer, anvil, and stirrup). These bones are bound together and attached to the walls of the drum cavity by ligaments. They are arranged in such a way that when the drum membrane is made to vibrate by sound waves, the motion is communicated by them to the cochlea. The cochlea is given this name because it is shaped just like a snail shell. It contains a great number of nerve fibers of different lengths and is thought to be that part of the ear which distinguishes musical notes.

(3) The cochlea is situated at the entrance to the inner ear, which consists of small bony spaces and tubes called the bony labyrinth, within which is a membranous labyrinth. The membranous labyrinth is lined with very sensitive cells, between which are the endings of the nerve fibers that connect the ear with the brain.

We can now get some idea of what takes place every time we hear a sound. The vibrations or sound waves are concentrated by the outer ear. They strike upon the drum, and are communicated from it to the chain of small bones which transmit it to the inner ear, where it makes an impression upon the sensitive nerve endings.

This impression is transmitted through the auditory nerve to the brain, producing the sensation of sound.

The ears have no lids or natural covering by means of which they can shut out sound as the eyelids shut out light. The nerves of the ear remain active during sleep, reporting all noises to the brain. The sounds to

IN TESTING A PERSON'S HEARING BE CAREFUL TO HAVE HIM CLOSE HIS EYES, SO THAT HE CANNOT SEE HOW NEAR OR FAR AWAY THE WATCH IS. WHY?

which one is accustomed do not prevent sleep, although impressions brought to the brain through the ear are often curiously woven into dreams. Unusual sounds generally cause awakening. Why, do you think?

An examination of hundreds of children in Europe showed that one quarter of them were a little deaf, many of them without knowing anything about it. Children are sometimes thought to be dull and inattentive when the real trouble is that they do not hear well what is said to them.

The care of the ears.

THIS BOY PROBABLY HAS A DEFECT IN HEARING.

It is a good thing to have the ears tested to find out if the hearing is perfect. A simple test which you can make for yourself is to find out how far away you can hear the ticking of a watch. If your hearing is good, you should be able to hear the watch when it is held as much as fifty inches from your ear. If you hear very much better with one ear than with the other, or if you

can not hear the watch tick at a distance of more than thirty inches, your ears should be examined.

Sometimes a cold will cause deafness for a time. Catarrh of the nasal passages or of the throat may spread to the eustachian tube and cause serious trouble. One who wishes to have good hearing will be careful not to take cold.

Children sometimes shout or blow into each other's ears for fun. This is very dangerous. It may send such a strong air current down the canal as to rupture the drum membrane and cause total deafness. A blow on the ear or on the side of the head may also seriously injure the ear.

The drum may be torn and the hearing injured by using a sharp instrument, such as a pin or a toothpick, to clean out the ear. The wax in the ear is placed there by nature as a protection and should be left undisturbed. If the ears are carefully washed and wiped out every day, there will be little danger that it will harden and cause trouble.

If anything accidentally gets into the ear, do not work at it. Hold the head over to one side while water is made to run in from a syringe. If an insect gets in the ear, a little oil will either kill it or make it come out.

Health Problems

1. How do blind people manage to get around? If a person were born blind, do you think he would have any images? Why?

2. How do deaf people manage to adapt themselves to people and things around them?

3. Why is it not possible to make much sound with a drum unless the head is taut?

4. See if you can prove that the head of the drum vibrates when it is struck. See also if you can prove that a tuning fork vibrates when it is giving forth sound.

5. Show whether the receiver of the telephone is like the drum of the ear in any respect.

6. Is "ear drum" a good term to apply to the membrane in the ear upon which sound waves strike? Why?

7. Try to imagine what goes on in the ear when one is walking along a very noisy city street. Do you think this is good for the ear? Why?

8. It is said that sometimes a cannon bursts the ear drum of the gunner. Explain.

9. Suppose the outer ear should be lost. What would be the effect upon the hearing?

10. Suppose you go from some level plain to the top of a high mountain. Which way will the ear drum bulge? Why?

11. When people in crossing the mountains have trouble with their ears, physicians always try to open up the eustachian tube. Why?

12. Why can one usually sleep soundly when the wind is blowing moderately or when his bedroom is near a lake or river, and the water is lapping on the shore?

13. Why is a sleeping person usually awakened when people come into his room, though he may not be awakened when there is a great deal of noise made outside?

Review Questions

1. Which organ gives the sensation of light? Which one gives the sensation of sound?

2. How are sensations caused?

3. Describe the experiment which was made to show what it is that gives sensation of sound.

4. What is meant by vibrations in the atmosphere? What is meant by sound waves?

5. How can one illustrate the traveling of sound waves by throwing a stone in the calm water of a pond?

6. How do the sound waves in the air give a sensation of sound? What is meant by the ear drum?

7. Why is it that some sounds are higher than others?

8. What is the smallest number of vibrations a second that the ear can hear? What is the largest number?

9. How is it possible that we can recognize the voice of a familiar friend?

10. What is meant by the outer ear?

11. Where is the auditory canal?

12. What is meant by the middle ear?

13. Where is the eustachian tube? How does it assist the hearing?

14. What is likely to happen when the eustachian tube gets blocked up?

15. How can the density of the air in the ear be changed voluntarily?

16. Describe the three small bones in the middle ear.

17. What is the cochlea? Why is it given this name?

18. What is the bony labyrinth?

19. What is the membranous labyrinth?

20. Just what takes place in the ear when we hear a sound?

21. Is there anything in the ear corresponding to the eyelid which covers the eye?

22. Can one shut out noises during sleep?

23. What kind of noises are likely to keep one awake?

24. How many of the children examined in Europe were found to be deaf?

25. What is the effect of deafness upon one's mind?

26. How can one test his hearing to find out whether it is normal?

27. Why will a cold sometimes cause deafness? It is said that catarrh often causes deafness. How is this possible?

28. Should children shout in the ears of one another? Why?

29. What may be the effect upon the ear drum of a blow on the ear? What is the danger of using a tooth pick or a pin in the ear?

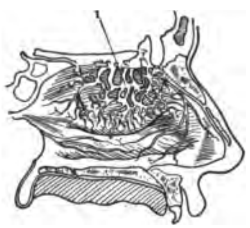
30. What is the purpose of the wax in the ear? How should it be removed when necessary?

CHAPTER XV

Gateways of the Mind,—Touch, Taste, and Smell

Perhaps you know that the sense of smell does not play nearly so important a part in the life of human beings as it does in the life of some of the lower animals. Do you think it may be that it has been largely lost in man through neglect of use? In a dog this sense is so acute that it seems to be of more service often than the sense of sight.

The olfactory nerves, or nerves of smell, end in the mucous membrane of the upper part of the nasal cavity. Here are situated delicate cells very sensitive to odors. These are the only nerve cells in the body exposed to the outside world. From the olfactory cells in the nose nerve fibers pass to the brain.



This illustration shows the olfactory nerve endings in the mucous membrane of the nasal cavity.

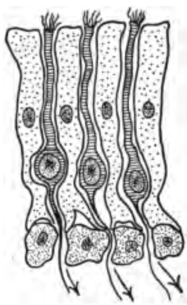
The sense of smell is excited only by very small particles of certain substances brought to these sensitive cells by moving air. This is why we "sniff" the air when we wish to smell anything.

When substances having an odor are held in the mouth, the particles that give the sensation of odor

are carried through the nose by the outgoing breath. Those sensations of smell we often confuse with taste.

Confusing smell and taste.

We frequently think we taste something which in reality we only smell. Try holding the nose so that the breath cannot escape through it, while a piece of onion is held on the tongue. You will then not notice any of the flavor of the onion. When the nose is obstructed by a cold the sense of smell is greatly lessened or even lost for a time. At such times the most highly flavored substances seem to have no taste.



THE OLFACTORY MUCOUS MEMBRANE. NOTICE HOW THE NERVE ENDINGS ARE EXPOSED TO THE AIR.

Neglected colds, which result in chronic catarrh of the nasal passages, may lead to entire loss of smell.

Destroying the sense of smell.

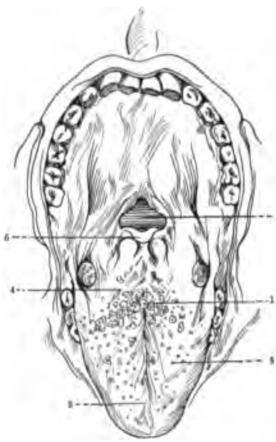
The mucous membrane may become thickened, so that the odorous particles carried by the air can not come in contact with the nerves of smell. The use of snuff and cigarette smoking are also likely to be destructive to this useful sense. Tobacco smoke has a paralyzing effect upon the nerves, besides inflaming the mucous membrane.

The brain receives valuable information through the sense of smell, as well as the pleasurable sensations caused by delightful odors. It helps us in determining whether articles are fit for food. Food that is beginning to spoil usually gives forth an unpleasant odor. The sense of smell also warns us of the presence of poisonous

gases in the air. It is a signal placed at the entrance of the body, and its warnings should be promptly heeded. When neglected, it soon ceases to give warning of the presence of danger. This is shown by the sensation experienced on entering an unventilated bedroom, or a crowded room, after a walk out-of-doors. One is surprised that the persons in the room can endure the unpleasant odor which he at once recognizes. But if he remain in the room for some time, he soon becomes as unconscious of it as the others.

The sense of taste, a sentinel of the body.

Examine your tongue, and you will find on its upper surface many little prominences which are called papillæ. If you look closely enough, you will notice some large papillæ that project quite prominently above the others. These large ones are called the papillæ circumvallate, because there is a little valley or furrow surrounding each one. The purpose of this little trough is to receive the fluids of the mouth in which are dissolved the savory substances of the food. In the trough are the taste buds, each one of which is the expanded end of a bunch of nerves. These taste buds are made up of thousands of delicate nerve filaments



NOTICE THE PAPILLÆ ON THE TONGUE.
1, lingure; 2, point of tongue; 3, papillæ; 4, base; 5, epiglottis; 6, orifice of pharynx.

which by means of their arrangement are brought into direct contact with the liquids containing the flavors of the food. If these sensitive, jellylike masses were right on the surface of the tongue, they would soon be injured. They are protected by being hidden away down in this little groove.

The flavor of many substances that we think we taste is really due to their odor, as we noticed above. There are only four true taste sensations: sweet, sour, salt, and bitter. It has been shown that each of these flavors is recognized by a special set of nerves. Bitter is most distinctly recognized at the back of the tongue, and the other flavors at the tip and sides.

Should you expect that condiments, such as mustard and pepper, and all substances which burn the tongue, would injure the nerves of taste and lessen their ability to recognize flavors? Why? Should you expect that alcohol would paralyze the nerves of taste? Why? A teaspoonful of alcohol held in the mouth for a few minutes will so benumb the nerves that ordinary flavors cannot be detected. The habitual use of alcohol permanently injures this valuable sense.

The sense of taste is given to us not merely as a means of pleasure but as a guide to our appetites. It is one of the body's most important safeguards. We have the old proverb, "Hunger is the best sauce," because when one is hungry almost any sort of wholesome food may be eaten with relish. When the sense of hunger is satisfied the food no longer tastes good.

A natural taste is a sentinel which promptly gives notice to the eater when he has taken enough of any sort of food to satisfy his present needs.

The sense of touch. Another important avenue to the mind, through which a great amount of valuable information comes to us, is the sense of touch. The nerve endings of this sense are in the skin. When these nerves are most abundant, the sense of touch is most acute, — in the ends of the fingers, the lips, and the tip of the tongue. When we touch anything, the outer skin or epidermis is pressed upon these nerve endings, and an impulse is started to the brain, causing a sensation of feeling.

The mind is able to judge of many things through the sense of touch. By its aid we are able to distinguish the forms of objects, whether they are smooth or rough, hard or soft, rigid or elastic. A little baby, reaching out with its hands to take hold of everything it sees, is making an unconscious effort to inform its mind and develop its judgment by means of this sense.

The delicacy of the sense of touch may be greatly increased by cultivating it. In the blind, in whom it has to take the place of the sense of sight, it is very acute.

The practice of training the sense of touch alone is shown in the case of Helen Keller, who lost both sight and hearing before she was two years old. From that time the only avenue to her mind (with the exception of taste and smell) was the sense of touch. Yet she

has passed successfully through all the stages of an ordinary college education and has become better informed than most persons having the use of all their senses. It has often been said of her that she "sees more with her fingers than other persons with their eyes."

THE SENSE OF TOUCH IN THE BLIND IS VERY ACUTE.

The sense of temperature.

Besides the nerves that are stimulated by touch, there are others in the skin that are stimulated by heat and others by cold. It is a curious fact that warmth and cold are not felt on the same spot of skin. The hot spots and cold spots are arranged in curved lines or chains, starting from the hair roots.

The effect that may be produced upon the body by means of temperature, acting through the nerves that carry to the brain the sensations of heat and cold, has already been studied. We have seen that by the stimulation of these nerves, impulses may be carried to every organ and tissue, increasing the blood circulation and exciting every kind of bodily activity.

A daily cold bath is a training of the nerves and the

brain, as well as of the skin and its vessels. The impression made by the contact of the cold water with the skin sends a thrill from the surface to the center, reaching every nook and corner and stirring every cell and fiber of the body. By this means the whole body is aroused and energized.

The use of pain.

Another sensation with which we are all familiar is pain. It is not known whether this sensation has its own special sets of nerves, but it is thought that it is caused by too great stimulation of any of the nerves of feeling. Although unpleasant and hard to bear, pain is one of the most useful sensations that we experience. It is a danger signal, calling our attention to the fact that something is wrong and needing attention.

Pain is often a means of preserving the body from serious injury. For example, if it were not for the pain caused a little child with no experience by burning, the child might keep its hand in the fire until it was destroyed. Toothache is a warning that a tooth is beginning to decay, a fact that otherwise might not be discovered in time to save the tooth.

People often try to stop or kill pain by drugs or other means, but pay no attention to the trouble of which the pain is giving them notice. This is as foolish as it would be to kill a sentinel because he gave us warning of an approaching danger, while we made no effort to avert the danger.

The purpose of a sensation of pain is to tell us that

there is something wrong with the body or with our way of treating it. The thing to do is not to take some kind of "pain killer" but to find out what is causing the pain and try as far as possible to have it remedied. This can often be done only by consulting a reliable physician.

Health Problems

1. How does an animal like the dog use the sense of smell? Suppose the animal should lose this sense, could it get along without it? Why?

2. Do you think the horse makes use of the sense of sight more than the sense of smell? Give reasons for your answer.

3. We say that animals "prick up their ears" when their attention is attracted by any noise. Do they do anything resembling this when their attention is attracted by odors?

4. A lion when he is stealing upon prey, or a hunter when he is tracking an animal, approaches from the opposite direction from which the wind is coming. Why does he do this?

5. Suggest two or three good tests to show how the sense of smell helps the sense of taste. Does food with a disagreeable smell ever have a good taste? If you think so, give an example.

6. Why has Nature arranged it so that taste and smell work together so closely?

7. Why has Nature arranged it so that some odors are very pleasant while others are very disagreeable?

8. Try a bitter tasting object on the tip of your tongue to see if you can detect it.

9. Put something sour as far back on the tongue as possible to see if you can taste it. Explain.

10. You might try the experiment of putting pepper on some article of food so that it will burn the tongue, then see if you can

get the taste of bread or any other article, as well as you could before you took the pepper.

11. Why did Nature arrange it so that an article of food would lose its taste when enough of it was eaten?

12. When the epidermis is rubbed off in an accident, why is the exposed part so painful to the sense of touch?

13. Why has Nature made the sense of touch so acute in the tips of the fingers, in the lips, and so on?

14. In what parts of the skin is the sense of touch very dull? Explain.

15. Can you think of any way to show that cold, heat, and touch are not recognized on the same spot on the skin?

16. Why does cold air usually give one a good appetite?

17. Mention some useful pains. Why should they be useful? Should we try to avoid them? Why? How can we do so?

Review Questions

1. How is it possible for odors to make an impression on the brain?

2. What is the meaning of olfactory? What are the olfactory cells? The olfactory nerves?

3. How is the sense of smell excited?

4. Why do people "sniff the air" when they want to smell anything?

5. When one has a cold or catarrh, why do pleasant tasting things often lose their taste?

6. What is likely to be the effect of cigarette smoking and snuff taking upon the sense of smell?

7. Can the sense of smell become accustomed to disagreeable odors so that one cannot detect them? Give illustrations.

8. If you examine the surface of the tongue, what do you find there?

9. How has Nature arranged it so that we can taste things?

10. Where are the taste buds? Of what use to us are they?

11. Suppose the taste buds were on the surface of the tongue, what might happen to them?

12. What are the true taste sensations?

13. On what part of the tongue is sour recognized? Where are the other flavors recognized?

14. What is the effect of condiments such as mustard and pepper on the sense of taste?

15. What is the effect of alcohol on the sense of taste?

16. Why is the natural taste a sentinel?

17. Where are the nerve endings for the sense of touch?

18. Where is the sense of touch most delicate?

19. What can the mind find out about objects through the sense of touch?

20. What is meant by the "sense of temperature"?

21. What effect may be produced on the body by cold?

22. Why will a cold bath stir up every part of the body?

23. What is meant by the sensation of pain?

24. Are pain sensations useful to the body? Explain.

25. Is it advisable to try to kill pain by the use of drugs? Why?

CHAPTER XVI

The Body's Enemies — Alcohol and Tobacco

The first thing to do for any one who wants good health is to guard against the enemies of the body. We have already learned about some of these enemies; but we must give special attention in this chapter to certain enemies, because of the great harm they will do the body unless we can avoid them.

There are certain poisonous substances, very harmful to the body, which are yet capable of giving rise for the moment to pleasurable sensations. They give one a feeling of happiness, wellbeing, or comfort. For this reason, they have come to be largely used by human beings, in spite of their poisonous character. Among those chiefly used in this country are alcohol and tobacco.

Alcohol comes of a bad family. It is closely allied to naphtha, benzine, and kerosene, which no one would think of drinking. In a pure state, alcohol destroys instantly all living tissues with which it comes in contact. It is seldom found pure, usually containing from two to fifty per cent of water.

If a plant be watered with diluted alcohol, its leaves

will soon wither, turn yellow, and the plant will die.

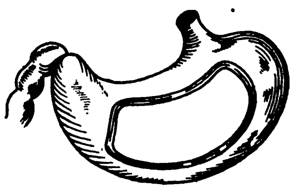
Alcohol kills living things.

A tadpole dropped into a vessel containing alcohol will die in a minute. Alcohol, taken even in small doses, has an injurious effect upon the living tissues of the body. A curious accident which happened to a hunter many years ago made it possible to find out the exact effect which alcohol has upon the stomach. A Canadian trapper and hunter, named Alexis St. Martin, was shot in the stomach. The wound was so large that the flesh did not close up and heal the wound in the usual way. It healed only the edges, leaving a hole two and one half inches around. A piece of lining of the stomach hung down and formed a kind of curtain over the opening. This could be pushed back so that one could look in and see what went on in the stomach, just as Professor Pawlow was able to look into the stomachs of his dogs.

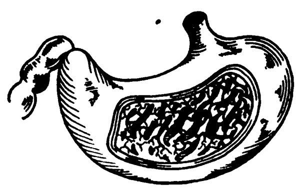
Dr. Beaumont, a physician in the United States Army, invited this man with a window in his stomach to come and live with him. He wanted to be able to look in whenever he pleased, and see just how the stomach acted under different conditions. Among other things, he wanted to find out if alcohol was helpful to the stomach in its work or if it hindered it and injured it.

Dr. Beaumont noticed that when Alexis was given good food with no alcohol, the stomach lining was of a pink color, and the gastric juice was thin and colorless. Then he tried giving him a certain amount of alcohol

every day. He then noticed that the lining became of a red color, because it was irritated and inflamed by alcohol. After a while, small sores or ulcers formed on it. He removed some of the gastric juice with a tube and found that it contained a thick mucus and sometimes blood from the sore places. He then stopped giving him alcohol and the stomach gradually healed and returned to its natural pink color. By this Dr. Beaumont knew that the continued use of alcohol causes disease of the stomach.



A HEALTHY STOMACH.



THE STOMACH OF A DRUNKARD IS INFLAMED AND ULCERATED.

Alcohol does more than simply irritate and inflame the stomach. It is able to paralyze the nerves so that they will lose their sensibility. On one occasion, when Alexis St. Martin had been drinking heavily for several days, Dr. Beaumont noticed that his stomach was much inflamed and ulcerated, but Alexis himself knew nothing about this. He felt no pain or discomfort in his stomach but only complained of a severe headache.

Some of the effects of alcohol upon the human body.

The liver, as well as the stomach, is injured by the

use of alcohol. In one who indulges in alcohol for years, it becomes shrunken, hard, and almost useless. The outside becomes covered with little knobs so that it looks like the sole of an English cartman's shoe. For this reason it has been given the name of "hob-nailed liver."

Alcohol has the effect of hardening the tissues. The brain in a healthy state is so soft that it would not retain its exact form if it were not supported by the skull. The sharpest knife is required to cut it without tearing it. If a careful examination of a brain is to be made, it is necessary to put it in alcohol for weeks or months in order to harden it. But the brain of a drunkard is already more or less hardened. An anatomist declared that he could tell the drunkard's brain in the dark by the sense of touch alone.

Experiments upon living animals have shown the changes that take place in the nerve cells when alcohol is introduced into the circulation. Some of them almost immediately become shriveled, misshapen, and incapable of performing their duty. The delicate branches by which the cells come in contact with each other are drawn back. The contact of the cells is thus interrupted, and this interferes with memory, reason, and judgment. This explains, as we have seen, the mental disturbances which take place in one who drinks freely of alcoholic beverages.

When an animal experimented upon with alcohol recovers from an intoxicating dose, the nerve cells

regain their natural appearance. But when the use of alcohol is habitual and long-continued, some of the cells become permanently injured. Then the brain, mind, and character are permanently changed.

A man who is intoxicated is for the time insane. When the intoxication is frequently repeated, this condition of mind may become permanent, making him a fit subject for an insane asylum. It has been shown that from 25 to 50 per cent of the people in the insane asylums of this country and England were brought there by alcohol.

Life insurance companies know that one who uses alcohol is not a "good risk." He is not likely to live so long as one who does not. Statistics based on their tables show that for every temperate person who dies between the ages of twenty-one and thirty, fifty-one intemperate persons die. In other words, for persons of this age, the mortality of liquor users is five hundred per cent greater than abstainers. It has also been shown that at twenty years of age, a temperate man has an average chance of living for forty-four and one fifth years, while the drinking man has the prospect of only fifteen and one half years.

The effects of alcohol are often seen even more plainly in the children of those who use it than they are in themselves. Dr. Hodge, Professor of Physiology in Clark University, was asked to make some experiments with animals to find out some of the effects of alcohol. In some of his experiments he used four dogs. Two

of these were given alcohol every day with their food, and for this reason he called them Bum and Tipsy. The other two were Nig and Topsy. During the four years that they were all under Dr. Hodge's care, Bum and Tipsy had twenty-three puppies. Some of these were dead when they were born and many of them were deformed. Only four lived to grow up. During the same time Nig and Topsy had forty-five puppies, all of which were born alive. Only four were a little deformed, and forty-one lived to grow up.

A French physician, Dr. Legrain, made some investigations to find out what effect it had upon the children when the parents used alcohol freely. This is what he found: "In the first generation from inebriety the mental and physical degenerates were 77 per cent of all; in the second generation, 96 per cent were defectives; in the third generation not one escaped; all were idiots, insane, hysterical, or epileptic."

Alcohol a deceiver.

All these things show us that alcohol is a deceiver; it only increases all the miseries that it promises to relieve. It relieves hunger, because it takes away the appetite and the power to digest food; but it does not nourish the body. It soothes pain by paralyzing the nerves, but it does not remove the cause of the pain. If a man is cold, it gives him the sensation of warmth, but he is actually colder than before. It makes the weak man feel strong, but he is actually weaker than before. It causes the nerv-

ous system to lie and to make a man think he is happy, while he is all the time becoming more wretched.

In 1862 the attention of the French Emperor was called to the fact that the number of lunatics, paralytics, and epileptics in the hospitals of France was five times as great in proportion to the population as it was thirty years before. There was also, it was noticed, about five times as much tobacco being used as thirty years before. It was thought that there might be some connection between these two things, and the Emperor appointed a committee of scientific men to make an investigation.

Tobacco a cause of disease.

In the course of this investigation, the students in the government training schools were divided into two classes — smokers and non-smokers. The physical condition of each class was carefully noted, as well as the amount of work they were able to do. It was found that the non-smokers were much superior, physically, mentally, and morally to the smokers. A law was at once passed forbidding the students in the government training schools to use tobacco.

Dr. J. W. Seaver, Professor of Physical Education at Yale, has made a careful study of the influence of tobacco upon the bodies and minds of the students. He found that during three and one half years of undergraduate life, the non-smokers increased in height 24 per cent more than the smokers; in girth of chest, 26 per cent more; and in lung capacity 77 per cent more.

It has been found that tobacco smoking in a boy affects some of the cells at the base of the brain and so interferes with the breathing and the action of the heart. The tissues do not get their full share of oxygen, and the blood is not distributed equally to all parts of the body. Any of the work of the body may be interfered with because of this.

A professor in the Kansas State Agricultural College recently examined the condition of 2500 school boys who smoked cigarettes. In one group of twenty-five school boys whose average age of beginning to smoke was thirteen years, he found the following conditions: sore throat, 4; weak eyes, 10; pain in chest, 8; short wind, 21; stomach trouble, 21; pain in heart, 9.

In the high schools in Wisconsin, it was found that nearly all of the boys who were dropped because of poor work or who were expelled for one cause or another were smokers. Those who used tobacco were almost always behind those who did not use it. In some places, boys under sixteen who use tobacco in any form will not be employed in any kind of work. Is this right? Why?

That many boys and young men are being injured by smoking was shown in the military examinations during the war with Spain. The examining physicians had to refuse a very large proportion of those who wanted to enlist in the army because they were suffering from "tobacco heart" caused by smoking.

These things show us that tobacco is another of the

deceiving drugs that promises happiness and brings trouble. It makes slaves of its young victims, while it gradually kills them.

Health Problems

1. If you can do so, put a little alcohol diluted one half with water on the leaf of a plant, and notice what happens to it.

2. Try putting some alcohol diluted one half on the roots of a growing house plant, and notice what happens to it.

3. Why is it impossible for a drunken man to reason or attend to his business?

4. Why is it that when many men are intoxicated they use vulgar speech which they would not use when they are sober?

5. Why do such men often want to engage in a brawl?

6. In some of the universities there are delicate instruments which are used to see how quickly one can act upon a sign and how quickly he can choose between lines of action. It has been found that alcohol always interferes with acting quickly and choosing wisely. Explain.

7. Why will a man on an athletic team be instantly dismissed if he is caught indulging in alcoholic drinks?

8. Why do some men who get drunk treat their families brutally?

9. Judges say that most crimes are due to the use of alcohol. Should you expect this? Explain.

10. Is there any law in your community which forbids people under a certain age to use tobacco? Ought there to be such a law? Why? A school board in Wisconsin made a rule recently that no pupil in a school could smoke outside of his own home. Why did the board make such a rule as this?

11. In many of the high schools of this country, a boy who smokes can not be on any of the teams or receive any honors from the school. Why has this rule been made?

12. Sometimes you hear men say that after they have stopped smoking for a while and they take it up again they are made sick for a while by a cigar or pipe. Explain.

13. Why is it that many smokers do not consider the rights or feelings of others, but blow smoke in their faces in cars, on the street, and so on?

14. China is doing everything it can to drive opium out of the country, because the Chinese say it has held back their people for many centuries. Do you think that tobacco may have much the same effect upon people in our country, if we do not get rid of it?

15. Write an essay on this topic: "Why Alcohol and Tobacco are Enemies of the Body."

Review Questions

1. What poisonous substances may give pleasurable sensations for the moment?

2. To what family does alcohol belong?

3. What will alcohol in a pure state do to any living tissue with which it comes in contact?

4. Describe the accident which happened to Alexis St. Martin and the study that was made of his stomach.

5. What was found regarding the effects of alcohol on the stomach of St. Martin?

6. How does alcohol affect the nerves?

7. How does alcohol affect the liver?

8. What is meant by "hob-nailed liver"?

9. If you put the brain in alcohol, what change will take place in it?

10. Why can an expert tell a drunkard's brain in the dark by the sense of touch alone?

11. What happens to the nerve cells when alcohol is put into the blood?

12. How is it possible for a man who is drunk to become sober again?

13. What may happen to the nerve cells if a man continues to drink beer, whisky, and the like?

14. Of what terrible disease of the mind is alcohol often the cause?

15. What do life insurance companies say about the use of alcohol? Will they insure a man who does not drink liquor for less than they will insure one who does? Why?

16. Is it right to speak of alcohol as a deceiver? How does it deceive one?

17. What did the French government find about the effects of tobacco upon the nerves of the people of France?

18. Why was a law passed in France forbidding the students of government training schools to use tobacco?

19. What has Doctor Seaver, of Yale University, found regarding the effects of tobacco?

20. Why is it that when a boy smokes there is likely to be a disturbance of his breathing and his heart?

21. What was found out by the professor in the Kansas State Agricultural College about the effects of smoking on the health of boys?

22. What was found regarding the use of tobacco by school boys in Wisconsin?

23. What was shown regarding the effects of tobacco on boys and young men during the war with Spain?

CHAPTER XVII

The Body's Enemies — Disease Germs

In this chapter, we must bring together all we have learned about those deadly enemies of the body, disease germs, and add some new facts. When there is an outbreak of disease in a community, some of the people exposed to the germs take the disease, become very sick, and perhaps die, while others escape entirely. Why do not all the people exposed to the germs become sick?

The germs of many diseases can be seen and studied with the aid of a microscope.

A healthy human body is able to defend itself quite well against all kinds of germs. Only when they attack in

overwhelming numbers, or when the natural defenses of the body have been weakened, are they able to gain a foothold in the body. Yet in the warfare that is constantly going on between mankind and these invisible foes, a large part of the human race is killed. What are some of the reasons for this?

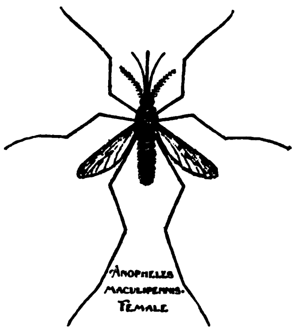
You know already that when we speak of disease germs we refer to those little plants (bacteria) and animals (protozoa) that are capable of growing in the bodies of human beings and animals and causing disease. Where are these most likely to be found?

You have learned that the germs of tuberculosis may be blown about in the dust of the street and that typhoid fever germs may be carried by water. Scarlet fever and other disease germs may be found in milk. Diphtheria germs have been found on drinking cups. The germs are conveyed to these places in some way from the bodies of persons sick with these diseases. The only place where the disease germs can multiply is in the bodies of the sick. You can see, therefore, why it is of the utmost importance that all material coming from the bodies of the sick should be disinfected or destroyed so that the germs may not be scattered about to infect other people. If this were always done as it should be, do you think that many diseases might be completely stamped out in a short time? Mention some of them.

The germs of different diseases have different methods of getting into the body. To know the ways

in which they are most likely to enter may help us to guard against them. Some may be introduced by the bites of insects. A certain kind of mosquito spreads the germs of malaria. Another kind introduces into the body with its bite the germs of yellow fever. Fleas spread the germs of plague. It has been found that infantile paralysis has in some cases been caused by the bite of the stable fly. Sometimes pus-forming germs work their way into the hair follicles and sweat glands of the skin or they may get in through scratches or wounds. The germs of colds, tuberculosis, pneumonia, influenza, and other diseases come in through the air passages. Typhoid fever and cholera germs get into the body with the food.

How germs enter the body.



A DISEASE CARRIER.

When the disease germs once get a foothold in the body, the mischief they are able to work is due to two things: (1) The great rapidity with which they multiply; and (2) their power to produce deadly poisons.

You may recall how the cells of the body multiply, — by each cell's dividing into two. Most disease germs multiply in the same way, and, as you already know, at a very rapid rate. The germs of cholera, for instance, may become full grown and divide into

two in twenty minutes. In this way they can extend their ravages in the body with great swiftness.

The weapon used by our germ enemies in their attack upon the body is the deadly poisons which they produce. It is these toxins, as they are called, which are very violent poisons, that really cause the disease by poisoning the cells of the body. Almost all fevers are caused by these germ-formed poisons. Some germs produce stupefying poisons; others, irritant poisons; still others, paralyzing poisons. Each class of germ develops its own brand of poison.

How the body defends itself.

Even when a person is in good health, the healing or restoring process is constantly going on in his body in order to keep him healthy. When one has worked until he is exhausted, he must recover from his fatigue before he can undertake fresh work. The digestion of a meal leaves the stomach in a congested state, from which it must recover before it is ready to digest another meal. The body is being continually worn by its work and so it needs constant restoring. This work is done by what we call the natural forces of the body — the power of the body to heal itself.

The healthy body is also able to defend itself against germs in a variety of ways. The skin is an outer defense which in a healthy state cannot be penetrated by germs. The mucus of the mouth and nose has some power to prevent the growth of germs and even to destroy them. The cells which cover the 2000

square feet of lung surface are constantly engaged in capturing and destroying germs. The gastric juice is a powerful germicide, or germ killer, capable of destroying the germs of cholera, typhoid fever, and any other germs that are likely to get into it. The white cells of the blood are the special defenders of the body against germs that enter the tissues, and the blood serum also has the power to destroy germs.

When, through the weakening of the natural defenses, the germs are able to gain a foothold in the body, great injuries may take place. The germ poisons irritate or paralyze the tissues, and cause inflammation, congestion, pain, and other disturbances. A special work of healing is then necessary, and the body has to rally all its forces to meet and conquer the invading army. This it does in two ways: (1) By increasing the number of white cells; (2) by the formation of special germ-killing substances in the blood and antitoxins to act against the toxins made by the disease germs.

You remember how the white cells in the blood seem to be attracted to the germs that get into the body and how they inclose or swallow them. Then ensues a struggle in which the germ tries to kill the corpuscle, and the corpuscle tries to digest and kill the germ. The life of the person in whom this fight is going on depends upon which gets the victory, the corpuscles or the germs. All that the doctor or nurse can do is to help the body to summon all its natural forces, and

to try as far as possible to assist the little soldiers in their fight.

As each class of germs has its own particular poison, so the body produces a special germ-killing substance suited to the particular kind of germ by which it is being attacked. You know there are diseases, such as smallpox and scarlet fever, which a person usually has but once. A person who has had smallpox may afterward go among people suffering with this disease without any danger of infection. He has become immune to that disease; that is, that particular kind of disease germ can no longer grow and multiply in his body. The reason for this seems to be that the special substance required to kill that kind of germ remains in his blood through life and promptly kills any such germs that may enter. Some diseases we may

PEOPLE CAN BE MADE IMMUNE TO CERTAIN DISEASES BY VACCINATION.

have again and again, because the germicidal, or germ-killing, substance for those particular germs quickly passes out of the blood.

Guarding against disease.

Since we are in constant danger of attack from disease germs, it is necessary to be constantly on guard against them. What are some of the ways in which we may be protected from attacks of this sort? In the first place, by means of public hygiene or sanitation we may protect ourselves. The health and sanitary officers in a community may be looked upon as a sort of advance guard or scouting party. They go out, armed with microscope and test tube, to spy out the enemy, — to find out where the disease germs may be lurking and from what point they are likely to make their attack. If possible, they destroy them before they have a chance to do any mischief. When this is not possible, they warn the people so that they may be on their guard. They compel people to put a large label on the house when any one inside is sick from some infectious disease. They examine the drinking water and see that there is a pure supply or that the people are warned when it contains disease germs or parasites. They inspect the food supplies in the markets and stores and order any that is diseased or unfit for food to be promptly destroyed. When there is an outbreak of disease in a community, they search out the cause and see that it is corrected.

In the war between Russia and Japan (1904–1905)

the sanitary officers were always sent out in advance with the army scouts. They tested all the wells and labeled them so that the soldiers would know if the water was fit for drinking. They went with the foraging parties and sampled all the food, fruit, and vegetables sold along the line of march. They examined the sanitary conditions of every town before the army arrived. If there was any danger from infection, the place was quarantined and guarded. They were in the camps, teaching the soldiers how to protect themselves.

As a result of this careful attention to hygiene, the Japanese army lost scarcely a man from preventable disease. In the Spanish American war, the death rate from preventable disease was 70 per cent, — only 268 men were killed by bullets, while 3862 died in the hospitals. This will give you some idea of how much may be done by public hygiene to guard people from disease.

Domestic hygiene.

As we have public hygiene, so we must have domestic hygiene. You will recall that house dust is very dangerous. It contains germs brought in from the street on the feet, or that have floated in the air, particularly those of pneumonia and tuberculosis, two most dangerous communicable diseases. Sweeping and dusting are sometimes done in a way that only stirs up the germs, and keeps them floating about, instead of getting rid of them. The vacuum cleaner, which sucks up all the dust and scatters none of it, is

by far the best method of removing dust from curtains and carpets. The dustless duster or a damp cloth will remove the dust which the ordinary dry duster only stirs up.

The kitchen, pantry, sinks, closets, and cellars need frequent cleaning. Fermenting and decaying materials are always a source of germs, and they should not be allowed to accumulate. Cesspools should be situated far from the house and should be water-tight so that the soil about the house cannot become polluted with the drainage. Stables and animal pens should also be at a distance from the house and should be kept clean.

Sunlight is Nature's great disinfectant. It destroys germs brought in contact with it. So we should admit the sunlight to every room in the house, closets included, if possible. Let it do its disinfecting work in every nook and corner of the home. Fire is the best of all disinfectants. Germ-producing matter should be burned whenever possible. Ordinary boiling, continued for half an hour, will destroy all sorts of dangerous germs.

Personal hygiene.

Of more importance than either public or domestic hygiene is personal hygiene — the acquiring of those habits which will keep the germs out of the body and will keep up the natural power of the body to kill them if they should enter.

Mention some personal habits which may be a means of introducing germs into the body. Think of the ways

in which the hands may gather germs in the course of a day, — from door knobs, car straps, money, and the hands of other persons. Should there be disease germs among them, these may get into the mouth with the food or into the eyes if they are rubbed. The simplest and easiest method of disinfecting the hands is by a thorough washing with soap. This is especially necessary before eating. Drinking from a cup used by others is another way by which disease germs may get into the body. At school or when traveling it is always best to carry a private cup. Also avoid putting into the mouth pencils, money, or other articles that have been handled by others.

Keeping up body resistance.

Even with all the precautions that we have mentioned, it is not possible to keep the body entirely free from disease germs. There are usually present in the body germs capable of producing disease, waiting for a favorable opportunity to attack. These are not to be feared so long as the body is in such a healthy condition that its natural defenses are active. But to let the body get run down or weakened by bad habits is to open the gates to the enemy. This may be done by lack of exercise, bad food, overeating, insufficient sleep, bad ventilation, overwork, or by the use of alcohol. Show why in each case.

At the time that Doctor Hodge made the experiments with his dogs, there was an epidemic in the city of a disease to which dogs are subject. This gave the

doctor an opportunity to see what effect alcohol would have upon their resisting power. Nig and Topsy, who had no alcohol, were scarcely sick at all, and quickly threw off the disease, but both Bum and Tipsy, who were given alcohol regularly, had the disease in a very severe form, and were so sick that they were saved only by Doctor Hodge's careful nursing.

When one country is expecting war with another the standing army is carefully inspected to see that all its soldiers are well equipped and in good fighting trim. Care is also taken that the reserve forces shall be ready if called upon. It is just as important for us, subject as we are to the attacks of germs, to keep our standing army of body defenders in good condition and our reserve forces ready to be drawn upon if necessary.

Health Problems

1. What is the meaning of the natural defenses of the body? Is the term "natural defenses" appropriate? Why? Mention some of these natural defenses.

2. How do nurses and doctors generally avoid taking the disease from the sick person whom they treat?

3. In some cities they are building bungalows on the roofs of skyscrapers. The people who build these plan to live in them just as other people live in houses built on the ground. If you were living in Chicago or New York or any other large city, do you think it would be more healthful to live in one of these bungalows than in an ordinary house? Why?

4. Give arguments for and against the statement: "It is the duty of every one to keep well." Should not every person be free to catch a germ disease if he wished to do so? Why?

5. Suppose some one member of the family is always catching colds and coughs. What may be the explanation of this? How should such a person be treated?

6. If you were living in a malarial country, what gateway of germs to the body would you guard particularly? Why?

7. Suppose there was an epidemic of yellow fever in your community, what gateway to the body would you guard particularly? Why? Consider in the same way an epidemic of typhoid fever and of diphtheria.

8. Why did Nature put poison into the bite of a snake? Why did Nature give germs the power to generate toxins which poison the cells of the body?

9. Give an instance that you have observed of the powers of the body to restore itself. Also give an instance of the power of the body to heal itself from some severe injury or illness.

10. You often hear a person say; "I was all run down, and I caught a cold." Just what does he mean by this? Do people catch coughs and colds more frequently when they are "run down" than at other times? Why?

11. Speak of habits you observe in people which are likely to weaken their "natural defenses". Are such people often ill? Why?

12. Mention some common diseases which a person may have over and over again. Mention diseases which he is not likely to have but once in a lifetime, and explain.

13. Show how the sanitary officers in a community are much like the scouts and pickets in an army. Suppose the scouts and pickets should not do their duty, what might happen to the army? Might it be the same way in a community if sanitary officers were neglectful of their duty?

14. Suppose we could get rid of all diseases caused by germs. Would there be any diseases left? If so, mention some of them and tell how they would be caused.

Review Questions

1. When are germs likely to get a foothold in the body?

2. Do germs ever win in their war with the human race? Why?

3. What are the names used for disease germs? What does this name mean?

4. How may the germs of tuberculosis be spread? The germs of typhoid? Diphtheria?

5. What are the breeding grounds for germs that make people sick?

6. How do insects spread disease?

7. How do the germs of colds, influenza, and other diseases get into the body?

8. What are the two ways in which germs work their mischief in the body?

9. How do disease germs multiply? How rapidly do the germs of cholera multiply?

10. What are the weapons which germ enemies use to attack the body?

11. What is the meaning of toxins?

12. How does the body defend itself against its germ enemies?

13. What has nature provided in the body to kill disease germs? How do the poisons made by the germs work upon the body?

14. What are the chief defenders of the body against disease germs?

15. What can the corpuscles and antitoxins do to help the body in its fight against germs?

16. What does it mean to become immune to a disease? Why does a person have smallpox only once in a lifetime?

17. What are the means of guarding against germ enemies?

18. Tell about the care which the Japanese took to protect their soldiers against germ enemies.

19. What is meant by domestic hygiene? What are some of the ways in domestic hygiene for guarding against disease germs?

20. Mention several good ways to kill germs.

21. What is meant by personal hygiene?

22. Mention different sorts of habits of life which will enable one to fight disease germs successfully.

23. What does it mean to keep up body resistance?

24. What does it mean to "open the gates to the body's enemies"?

25. Mention various ways in which our body defenders can be kept in good fighting trim so as to ward off disease.

CHAPTER XVIII

"Catching" Diseases

The danger of contagious diseases.

No person would purposely plan to make a friend sick. Yet it often occurs, without any intent on his part, that one who is ill, through being with other persons, causes them to become ill too. This is because the disease he has is *communicable*, or can be passed from one person to another. In other words, it is a "catching" or *contagious* disease. Smallpox, measles, scarlet fever, diphtheria, chicken pox, mumps, and whooping cough are all *communicable* or *contagious* diseases. A child who has any one of these is a danger to other children until he is entirely well, even though he may himself not feel sick. Very severe cases often result from coming in contact with one of these diseases in a mild form.

Quarantine.

Those who guard the health of the people have made it a law that persons having a communicable disease shall, as soon as this is known, live quite apart from other people. This is called a *quarantine*, and it is necessary in order to prevent others from taking the same disease. With many children, quaran-

tine is the hardest part of the illness, since they must stay at home, and none of their playmates may come to see them. But when one thinks of the risk to others, he feels it is quite right that he should not see them.

My young friend Georgia, at school one day, complained of having a sore throat. Her teacher at once sent her home, although the girl said she did not really feel sick, and she begged to be allowed to remain. The teacher did not send her away because of her misfortune in having a sore throat, but as a precaution for the rest of the pupils. Did the teacher do the right thing to send Georgia home?

GEORGIA COMPLAINED IN SCHOOL ONE DAY OF HAVING A SORE THROAT.

How a "culture" is taken.

The teacher knew that sore throat is often a danger signal, and such it proved to be in Georgia's case. Soon after reaching home, she began to feel hot and feverish; and her mother called a physician. When the physician discovered that her throat was sore, he took a small wooden stick from his case. Around one end of this he wound some *sterile* cotton, that is, cotton free from all germs, and made a *swab*. With the swab he wiped the little

girl's throat. Afterward he put the substance wiped off on the kind of soil upon which germs like best to grow, — that is, upon a "culture" plate. If Georgia had diphtheria, as the doctor feared, this "culture" would, he knew, show it in a few hours. Diphtheria is always caused by germs. These germs grow on the mucous membrane of the mouth and throat. They are so tiny they cannot be seen with the eye alone. But if some of them are wiped off, and planted on "culture" soil, a microscope will reveal them as they grow. If the throat from which the culture is taken has no diphtheria germs, this, too, will be shown.

The doctor told Georgia's mother that until he could make a report on this case, she had best put Georgia in some room as remote as possible from those occupied by other people, and to take out of it all but necessary furniture. When Georgia's father built their cottage, he made one room in the upper story that opened upon a covered porch. It was also connected with a small bathroom. There were three nice windows, too, so there could be plenty of sunshine and fresh air. The room was at the end of a hall, and the family called it their "hospital corner," because in times of illness it could be fitted up very well for a sick room.

Georgia was put in this room for the night, after her mother had taken out all the extra things. In the morning, the culture taken from her throat showed for sure that Georgia had diphtheria, and the doctor

said she must not go from the "hospital corner" to any other part of the house, and no one but the nurse and himself could be allowed in the room with her. To prevent the risk of any other child's entering the room unawares, the nurse kept the door locked.

GEORGIA ON THE PORCH — THE "HOSPITAL CORNER."

Antitoxins and their use.

Diphtheria is a very "catching" disease. Now that it was certain diphtheria germs were making Georgia ill, the doctor said that she and every one in the house should have a dose of *antitoxin* (*anti* means opposed to, and *toxin*, poison), a remedy that works against the poison which diphtheria germs always make in the body.

It is only within recent years that it has been possible to secure this remedy. Before its use, only about one half of those who had the disease in severe form got well. But now thousands of lives are saved by the employment of *antitoxin*. The more promptly it is given, the better the results. Where it is used within the first twenty-four hours of illness, there is a loss of only one life in a thousand cases. Do you not think every one should make use of *antitoxin* when he is in any danger from diphtheria?

THE PHYSICIAN PUT UP THIS SIGN ON GEORGIA'S HOUSE. WHY?

It happens quite often that a person having diphtheria germs, although not at all sick himself, gives the disease to others. Such a person is called a *carrier* and is a danger to all his friends so long as he has the germs. His own body makes *antitoxin* enough to defend itself, but that does not mean safety for other

people. In some cities, when a case of diphtheria occurs in a school, cultures are taken from the throats of all in that room in order to find who the carrier may be. Carriers need to be quarantined, and have the germs in their throats destroyed the same as in the case of a person who is actually sick with the disease. Why?

Precautions observed in quarantine.

In the case of Georgia, the health officers had been notified of her illness, and a red placard was put on the door, warning all who came that way not to enter. Why? A notice was placed where the milkman could see it telling him not to leave bottles but to pour the milk into a dish placed specially for him. Why? A poster placed indoors gave directions to the family as to how they must care for themselves and for the diphtheria patient.

Some of the things it said were: —

"Diphtheria is always dangerous and easily given to others. It is catching from the mildest form. Those not sick enough to be in bed give the disease to others oftener than the very sick.

"Diphtheria patients must not leave the house until the Department of Health removes the warning card. Neither may people living in the house go in and out. Inmates of the house must stay indoors.

"Visitors are not allowed.

"Groceries and milk must be left at the door.

"School children and others must stay at home. No one living in the house is allowed to go to church, Sabbath school, or to other public places.

"Do not let the patient spit on the floor.

"Spit and nose discharges will give the disease to others, and should be caught on cloths, and burned immediately.

"Do not kiss the patient.

"After touching the patient or anything he handles, *always wash your hands*.

"Everything, — letters, laundry, bedding, books, magazines, papers, and clothing must be disinfected before they are taken out of the house.

"Everything used in the sick room, such as knives, forks, spoons, dishes, books, playthings, handkerchiefs, towels, sheets, pillow slips, clothing, flowers, and remnants of food must be disinfected before being taken from the room."

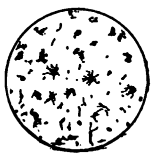
To disinfect an article, you will remember, means to do something to it that will kill all the germs on it. As we learned in Chapter IX, there are several ways of doing this. For instance, any article which will not be harmed by boiling may be disinfected in that way. So on a gas plate in the bathroom, Georgia's nurse kept a tin boiler full of water just at the boiling point. All the dishes and everything which Georgia used or touched were, as soon as she was through with them, put into this water, and boiled for twenty minutes.

When boiling is not convenient, a metal tub may be filled with some solution which the doctor will order, and all articles may be soaked in it for a time.

One thing is to be specially remembered whenever a person has a communicable disease: *nothing must ever be allowed to leave the sick room without first killing the germs on it by thorough disinfection.*

Georgia's father constructed a very good kind of

dumb waiter by means of which he might send meals up to the sick room. First, he attached a small chain to a large tin bread box. Then by fastening a pulley to the porch railing and adjusting the chain on it, it could be raised and lowered with ease. The nurse opened the box on the porch outside the door and emptied all foods into the special dishes kept there for Georgia's use and her own. Then she told the one below to lower the box. The nurse was always careful to disinfect her hands before touching the box or its contents, so that not a germ might find its way to the room below.



TYPHOID FEVER GERMS.

THE KIND THAT CAUSE TUBERCULOSIS.

How the disease was carried in Georgia's case.

The doctor was quite at a loss to know where Georgia could have got diphtheria germs, as no "carriers" had been found. There was not a case in that town, and there had been none for a long time. Neither had Georgia been away on any visits.

"Isn't it odd that my Cousin Ellen should be having the same disease that I am," said Georgia one morning during the doctor's visit.

"Where does your cousin live?" inquired the doctor.

"Way up in Canada," replied the little girl.

"Then how do you know she has been sick?"

"Oh, we write letters to each other. She wrote me that she was having to stay out of school because she

had been ill with diphtheria. It is just queer that the same thing has happened to both of us."

"How long since you got that letter?"

"Oh, about two weeks ago," replied Georgia.

"Well," said the doctor, "it does not seem at all queer to me. It is plain enough now that the germs which are causing you so much unpleasantness came to you sealed up in your cousin's letter. The strange thing is that her people should permit her to send letters while she was ill with a 'catching' disease."

"I guess, perhaps, they didn't know about it," said Georgia, "for Cousin Ellen wrote us that they would not let her go out at all, so she was going to drop her letter out of the window and ask the neighbor girl to post it."

"It would not surprise me if the neighbor girl, too, took diphtheria from that letter," said the doctor. "Diphtheria germs pass from the sick to the well so easily that everything touched by the patient is dangerous until the germs on it are killed. And, too, these germs live a long time."

Animals and playthings may carry germs.

A little boy I knew died from diphtheria. His mother, out of fondness for him, kept his picture blocks and books and toys in a trunk which she stowed away in the attic. Years afterward, some other little children playing in the attic found these playthings, and from them got the germs that made both of them very ill with diphtheria. These facts and many similar ones have made it plain that the greatest care must be taken with regard to

all the things that come into contact with those who are ill with diphtheria. The same is true in respect to other catching diseases. So you see it is best always to do exactly what the health boards and those who make a study of these diseases tell us, even though it is not very pleasant at the time.

"May I have my dolly to play with, while I am in quarantine ?" asked Georgia.

"You may have anything you want provided you are willing that it should be burned when you get well," replied the doctor.

"Oh, when shall I be well, then ?" she continued.

"When the cultures from your throat show that you no longer have diphtheria germs," was the doctor's answer. "No one can tell just how long that may be, but you can help things along by cheerfully taking your treatments and doing as your nurse tells you."

"And does everything I play with have to be burned ?" she asked again.

"Anything that can be boiled without harm can be saved," said the doctor. "There are other ways in which some things can be made safe, but in general it will be wiser to bring nothing up here that you will afterward need or care especially for. Your nurse knows so many nice things to do, you will not miss your dolly, I am sure."

Just then the barking of a dog below called Georgia's attention to her pet, and she asked, "Why doesn't somebody open the door for Gyp ?"

"Gyp is in quarantine, too," said the doctor. "He lives in the carriage house now. It would be unsafe to allow him in the house while there are diphtheria germs about. Animals as well as human beings take the disease. Even if Gyp did not catch it himself, he might be the means of giving it to some person, for the germs would get in his hair, and he would scatter them wherever he went. He is made quite comfortable and given plenty to eat, but he doesn't like to be shut out any better than you like to be shut in."

Every day a cot was placed in a quiet corner of the porch. On it Georgia was allowed to lie out of doors where she could watch all that was going on in nature around and breathe the fresh air.

When she was able to sit up, a large shallow pan of sand placed on a bedside table afforded her many pleasant hours of play. Out of it she made a farm with valleys and hills, rivers and lakes. For trees she planted green twigs. A cardboard house and barns, fences of toothpicks, and paper men, women, children, and animals made it seem quite real.

At other times the sand pan was an athletic field where paper boys played ball, or a park with flower beds, and winding paths, with cages of wild animals. Again it became a model town with broad streets, on which paper automobiles and trolley cars were seen. So many and varied were the things that could be made with that sand pan that Georgia quite forgot

she was in quarantine; and she was really a little bit sorry when one morning the doctor said to her, "You have a clean throat, and to-day, when your nurse has given you a cleansing bath all over, including your hair, you may put on clean clothing and go down stairs."

"May I go to school to-morrow?" she asked.

"Not to-morrow, but in a few days," was the answer. "Culture tests must be made again. The house, too, must first be cleansed of germs so that you will carry none to school."

Years ago people understood little about germs, and their part in the cause of diseases. They knew that certain diseases were "catching," and that these rarely attacked the same individual twice. It was a common belief that everybody must have measles, scarlet fever, whooping cough, chicken pox, and mumps, and the earlier in life each person took his turn the better it would be for him. Little care was taken to avoid diseases, and sometimes children were sent to visit the sick in order to catch their disease. I suppose you do not need to be told that very many lives were lost through such ignorance.

In these days it is known that children are likely to grow up stronger and in better health if they do not have these diseases. It is known, too, that if ever they have the misfortune to catch any of them, the older they are at the time the better able they will be to fight the germ poison of the disease.

Health Problems

1. Have you or your family ever been *quarantined?* If so, for what reason? How did you communicate with the outside world during the quarantine? Did you feel at the time that you were unjustly treated?

2. Are pupils ever kept out of your school on account of illness? Who forbids them to come to school?

3. Have you known of pupils who have come to school with contagious diseases and have given them to other pupils? Was this fair to the well pupils?

4. Sometimes when a contagious disease gets started in a school, the school board closes the school for a week or more. Why?

5. Have you been *vaccinated?* What good does vaccination do?

6. Have you known of any person who has been given *antitoxin?* If so, what was the reason that it was given to him? Do you know whether it helped him?

7. If you can do so, find out how antitoxin is prepared. Your family physician should be able to tell you.

8. If two people are exposed to diphtheria in the same way, one may catch it and the other may not. Why is this so?

9. Is there a medical inspector who visits your school? If so, state just what he does. If there is no such inspector, do you think one ought to be appointed? Why?

10. In some schools they have a "visiting nurse" who goes into all the rooms every day and takes a look at all the pupils. If she suspects any one of having a contagious disease, she makes a special examination to find out for sure. Do you think such a visiting nurse would be a help to your school? Why?

11. Have you ever heard of a person's being *immune* to certain diseases, such as whooping cough? What does this mean? How is it possible?

Review Questions

1. What is the meaning of *communicable* diseases ?

2. Mention some common communicable diseases.

3. Might a person who has one of these diseases, but who is not very sick, be a danger to other people, if he should play or study with them ? Why ?

4. What does it mean to be put in *quarantine?* Who is it in a community that puts a person with a contagious disease in quarantine ?

5. What diseases may one be getting when his throat begins to feel sore ?

6. How does a physician make a test for diphtheria ?

7. When is a thing *sterile?* How can one make a spoon, for instance, sterile ?

8. What is the meaning of a *culture?* How does a physician make a culture of diphtheria, for instance ?

9. What does antitoxin do in the body ?

10. Has antitoxin saved the lives of many people ?

11. May a person carry the germs of diphtheria, even if he is not sick himself ?

12. Why did the health authorities put a placard on the door of Georgia's house, warning people not to enter ?

13. Why did they forbid all the people in the house from going out on the street ?

14. What did they put on the poster which they placed indoors ? Why is it necessary to give these directions to a family ?

15. How does a nurse disinfect the articles used by a sick person ? Why was it necessary to be so careful about this ?

16. How do people get the diphtheria germs which cause sickness ?

17. Why are people often so careless about sending out letters and the like from those who are sick with contagious diseases ?

18. In an earlier day, did people think children ought to get all the "catching" diseases ? Why ?

APPENDIX

TABLES OF COMPOSITION OF FOODS

You should keep the following tables for reference, so that you can tell what nutrients are to be found in all the ordinary foods. The meaning of the figures in these tables is clear when you remember that for every 100 lb. of milk, eggs, etc., 87.0 lb. is water, 3.3 lb. is protein, etc.

Protein Foods — Composition

Food	Water	Protein	Fat	Carbohydrates	Ash Mineral
Milk	87.0	3.3	4.0	5.0	0.7
Eggs	73.7	14.8	10.5	0.0	1.0
Cheese	34.0	24.3	33.4	4.5	3.8
Fowl	63.7	19.3	16.3	0.0	1.0
Beef	61.9	18.6	18.5	0.0	1.0
Fish (lean)	82.6	15.8	.4	0.0	1.2

U. S. Department of Agriculture.

General Composition of Grains

Grains	Water	Protein	Fat	Carbohydrates	Cellulose	Ash Mineral
Bread, Graham (whole meal)	35.7	8.9	1.8	52.1	1.1	1.5
Macaroni	13.1	9.0	0.3	76.8		0.8
Wheat	11.4	13.8	1.9	71.9	.9	1.0
Oats (meal)	7.3	16.1	7.2	67.5	0.9	1.9
Barley	11.5	8.5	1.1	77.8	0.3	1.1
Corn (green)	75.4	3.1	1.1	19.7	0.5	0.7
Rice	0.3	8.0	0.3	79.0	0.2	0.4

General Composition of Fruits

Edible Portion Fruit	Water	Protein	Fat	Carbohydrates	Cellulose	Ash Mineral
Gooseberries	85.6	1.0		13.1		0.3
Currants	85.0	1.5		12.8		0.7
Whortleberries	82.4	0.7	3.0	13.5	3.2	0.4
Blueberries / Cranberries	88.9	0.4	0.6	9.9	1.5	0.2
Grapes	77.4	1.3	1.6	19.2	4.3	0.5
Blackberries	86.3	1.3	1.0	10.9	2.5	0.5
Raspberries (blk.)	84.1	1.7	1.0	12.6		0.6
Strawberries	90.4	1.0	0.6	7.4	1.4	0.6
Melons	89.5	0.6		9.3	2.1	0.6
Watermelons	92.4	0.4	0.2	6.7		0.3
Pineapples	89.3	0.4	0.3	9.7	0.4	0.3
Bananas	75.3	1.3	0.6	22.0	1.0	0.8
Apples	84.6	0.4	0.5	14.2	1.2	0.3
Pears	84.4	0.6	0.5	14.1	2.7	0.4
Peaches	89.4	0.7	0.1	9.4	3.6	0.4
Plums	78.4	1.0		20.1		0.5
Cherries	80.9	1.0	0.8	16.7	0.2	0.6
Oranges	86.9	0.8	0.2	11.6		0.5
Dates (dried)	15.4	2.1	2.8	78.4		1.3
Figs (dried)	18.8	4.3	0.3	74.2		2.4
Prunes (dried)	22.3	2.1		73.3		2.3
Raisins (dried)	14.6	2.6	3.3	76.1		3.4
Olives	67.0	2.5		9.0		4.4

The Composition of Legumes

Legumes	Water	Protein	Fat	Carbohydrates	Cellulose	Ash Mineral
Lima beans (dried)	10.4	18.1	1.5	65.9		4.1
String beans	89.2	2.3	.3	7.4	1.9	.8
Green peas	74.6	7.0	.5	16.9	1.7	1.0
Peas (dried)	9.5	24.6	1.0	62.0	4.5	2.9
Lentils (dried)	8.4	25.7	1.0	59.2		5.7
Beans (dried)	12.6	22.5	1.8	59.6	4.4	3.5

General Composition of Nuts

Edible Portion Nuts	Water	Protein	Fat	Carbo-hy-drates	Cellu-lose	Ash Mineral
Cocoanuts	14.1	5.7	50.6	27.9		1.7
Almonds	4.8	21.0	54.9	17.3	2.0	2.0
Pecans	2.7	9.6	70.5	15.3		1.9
Hickory nuts	3.7	15.4	67.4	11.4		2.1
Filberts	3.7	15.6	65.3	13.0		2.4
Brazil nuts	5.3	17.0	66.8	7.0		3.9
Chestnuts	45.0	6.2	5.4	42.1	1.8	1.3
Walnuts (black)	2.5	27.6	56.3	11.7	1.7	1.9
Peanuts	9.2	25.8	38.6	24.4	2.5	2.0

General Composition of Vegetables

Edible Portion Vegetables	Water	Protein	Fat	Carbo-hy-drates	Cellu-lose	Ash Mineral
Potatoes	78.3	2.2	0.1	18.4	0.4	1.0
Sweet potatoes	69.0	1.8	0.7	27.4	1.3	1.1
Carrots	88.2	1.1	0.4	9.3	1.1	1.0
Turnips	89.6	1.3	0.2	8.1	1.3	0.8
Radishes	91.8	1.3	0.1	5.8	0.7	1.0
Beets	87.5	1.6	0.1	9.7	0.9	1.1
Parsnips	83.0	1.6	0.5	13.5	2.5	1.4
Cabbage	91.5	1.6	0.3	5.6	1.1	1.0
Cauliflower	92.3	1.8	0.5	4.7	1.1	0.7
Spinach	92.3	2.1	0.3	3.2	0.9	2.1
Celery	94.5	1.1	0.1	3.3		0.1
Asparagus	94.0	1.8	0.2	3.3	0.8	0.7
Cucumber	95.4	0.8	0.2	3.1	0.7	0.5
Tomatoes	94.3	0.9	.4	3.9	0.6	0.5
Squash	88.3	1.4	0.5	9.0	0.8	0.8
Onions	87.6	1.6	0.3	9.9	0.8	0.6

General Composition of Fats

Fats	Water	Proteid	Fat	Carbo-hydrates	Ash Mineral
Butter	11.0	1.0	85.0		3.0
Olive oil			100.0		
Cream	74.0	2.5	18.5	4.5	0.5

Average Composition of Foods

	Fruit	Nuts	Legumes
Water	85–90%	4–5%	10–14.20%
Proteid	5%	15–20%	13.81–25.16%
Fat	.05%	50–60%	0.58–2.46%
Carbohydrates	5½–10½%	9–12%	52–12%
Cellulose	2½%	3–5%	2–3%
Mineral matter	.05%	1%	

GLOSSARY

KEY TO PRONUNCIATION

ā, as in **āle**; **ȧ**, as in **sen′ȧte**; **â**, as in **câre**; **ă**, as in **ăm**; **ä**, as in **ärm**; **ȧ**, as in **ȧsk**; *a*, as in fi′n*a*l; **ē**, as in **ēve**; **ė**, as in **ė-vent′**; **ĕ**, as in **ĕnd**; **ẽ**, as in **fẽrn**; *e*, as in re′c*e*nt; **ī**, as in **īce**; **ĭ**, as in **ĭ-de′a**; **ĭ**, as in **ĭll**; **ō**, as in **ōld**; **ȯ**, as in **ȯ-bey′**; **ô**, as in **ôrb**; **ŏ**, as in **ŏdd**; **ū**, as in **ūse**; **ů**, as in **ů-nite′**; **ŭ**, as in **ŭp**; **û**, as in **ûrn**; **ў**, as in **pĭt′ў**; **o͞o**, as in **fo͞od**; **o͝o**, as in **fo͝ot**; **ou**, as in **out**; **oi**, as in **oil**.

A

abdominal cavity (ăb-dŏm′ĭ-nal kăv′ĭ-tў). The hollow place in the body in which the organs of the abdomen are.

abscess (ăb′sĕs). A collection of pus in any tissue or organ of the body, due to infection.

adenoids (ăd′ė-noids). Growths that form in the nasal passages and interfere with breathing.

albumen (ăl-bū′mĕn). One element of food, found in the white of an egg, for instance.

alimentary canal (ăl′ĭ-mĕn′tȧ-rў kȧ-năl′). The whole length of the food channel extending through the body.

alkalinity (ăl′kȧ-lĭn′ĭ-tў). Having the quality of an alkaline substance, like soda, for instance.

amœba (ȧ-mē′bȧ). A tiny animal that consists of just one cell.

analogous (ȧ-năl′ȯ-gŭs). Having a likeness to something else.

anterior chamber (ăn-tē′rĭ-ẽr chām′bẽr). The enclosed space in the eye in front of the lens.

anvil (ăn′vĭl). One of the three small bones in the ear. This bone has a shape like that of a blacksmith's anvil.

apex (ā′pĕks). The tip, point, of anything; as the *apex* of the heart.

apoplexy (ăp′ȯ-plĕks′ў). The pressure of blood in the brain, which causes a blood vessel to burst.

aqueous humor (ā′kwė-ŭs hū′mẽr). A fluid in the eye which fills the anterior chamber.

assimilation (ăs-sĭm′ĭ-lā′shŭn). The process of changing blood into tissues and organs.

auditory canal (a̤′dĭ-tȯ-rў kȧ-năl′). The tube from the opening of the ear to the drum of the ear.

auricle (a'rĭ-k'l). One of the compartments in the heart, that receives the blood from the veins. Its name comes from its likeness to the outside ear.

B

bacteria (bȧk-tē'rĭ-ă). (The plural of bacterium.) Tiny plants that grow in the body. Some are harmful; some helpful.
biconcave disks (bī-kŏn'kāv dĭsks). Round plates hollowing in on both sides at the center.
bicuspids (bī-kŭs'pids). The two double-pointed teeth which grow, one on each side of the jaw, between the cuspids and the molars.
bile (bīl). A yellow or greenish fluid found in the liver; gall.
biliousness (bĭl'yŭs-nĕs). The state of the body when there is too much bile in the system.
bismuth (bĭz'mŭth). A substance used sometimes to observe the course which food takes in the alimentary canal.
bronchi (brŏn'kī). (The plural of bronchus.) The tubes that carry the air from the windpipe into the lungs.
bronchioles (brŏn'kĭ-ōles). Tiny bronchial tubes.

C

capillary (kăp'ĭl-lȧ-rў or ka-pĭl'la-rў). A tiny, thin-walled tube; particularly one of the smallest blood vessels connecting arteries and veins.
carbohydrates (kär'bȯ-hī'drȧts). Food elements including principally sugar and starches.
carbonic acid gas (kär-bŏn'ĭk ăs'ĭd găs). The substance which a plant takes from the air, and which is thrown off from the lungs of animals in breathing.
cardiac (kär'dĭ-ăk). Pertaining to the heart.
cartilage (kär'tĭ-lȧj). An elastic tissue found mainly in the body between joints and at the ends of bones.
cell (sĕl). One of the tiny structures that compose the greater part of the tissues and organs in the body.
cellulose (sĕl'ū-lōs'). One of the envelopes formed of a woody substance that encloses starch.
cerebellum (sĕr'ē-bĕl'lŭm). The little brain. It controls the action of the muscles.
cerebrum (sĕr'ē-brŭm). The larger division of the brain. It controls reasoning and willing.
choroid (kō'roid). The middle coat of the eyeball.
chyme (kīm). The name given to the food we have eaten when it is a half-digested pulpy mass. The food is in this state in the small intestines.

cilia (sĭl'ĭ-ȧ). (The plural of cilium, which is rarely used.) Tiny hairs in the air passages.
clot (klŏt). A thickened congealed mass, as a clot of blood.
cochlea (kŏk'lė-ȧ). The part of the ear at the entrance of the inner ear.
colic (kŏl'ĭk). A severe pain in the abdomen.
colon (kō'lŏn). A part of the large intestine.
combustion (kŏm-bŭs'chŭn). The process of burning.
contaminated (kŏn-tăm'ĭ-nā'tĕd). Made foul; polluted; stained; soiled; dangerous, as when milk or water is contaminated by germs of typhoid or other diseases.
convolutions (kŏn'vō-lū'shŭnz). Irregular winding folds of an organ; as the *convolutions* of the brain; the convolutions of the intestines.
cornea (kôr'nē-ȧ). The part of the coat of the eyeball which covers the iris and the pupil and lets in light to the inside of the eye.
cranium (krā'nĭ-ŭm). The skull; the bony case for the brain.
crystalline lens (krĭs'tal-līn or -lĭn lĕnz). The part of the eye that brings the rays of light to a point.
cuspids (kŭs'pĭdz). The teeth that have but one point (or cusp) on the crown.

D

dermis (dẽr'mĭs). The layer of skin beneath the scarfskin or epidermis.
diaphragm (dī'ȧ-frăm). The muscle that separates the cavity of the chest from that of the abdomen.
digestion (dĭ-jĕs'chŭn). The changing of foods into such form that the blood can absorb the useful parts and the body throw off the useless parts.
dilate (dĭ-lāt' or dī-lāt'). To enlarge, to swell; to expand.
duct (dŭkt). A tube or canal.

E

emulsified (ė-mŭl'sĭ-fīd). Subdivided into tiny particles, as when olive oil is emulsified in lemon juice.
enzyme (ĕn'zīm). A substance made by the salivary glands, which causes fermenting, and is necessary for the digestion of starch.
epidermis (ĕp'ĭ-dẽr'mĭs). The outer layer of the skin, the scarfskin.
epiglottis (ĕp-ĭ-glŏt'tĭs). The lid-like covering which closes the glottis while food or drink passes through the pharynx.
epithelial cells (ĕp'ĭ-thē'lĭ-al sĕlz). Cells that cover the surface of the body and line all the cavities of the body.
epithelium (ĕp-ĭ-thē'lĭ-ŭm). The covering formed by the epithelial cells.
esophagus (ė-sŏf'ȧ-gŭs). The part of the alimentary canal between the pharynx and the stomach; the gullet.
eustachian tube (ū-stä'kĭ-an tūb). The tube that leads from the ear drum to the pharynx.
excretion (ĕks-krē'shun). The act of throwing off, of discharging wastes from the body.

F

fiber (fī′bẽr). A delicate threadlike substance; especially the slender tissues which form muscular tissues.

G

gall bladder (gal blăd′dẽr). The sac in which the bile, or gall, is stored up.
gastric juice (găs′trĭk jūs). A thin watery fluid of an acid nature that flows from the walls of the stomach to mix with the food and aid digestion.
germicide (jẽr′mĭ-sīd). Anything that kills germs.
glottis (glŏt′tĭs). The opening from the pharynx into the larynx or into the trachea.
glycogen (glī′kṓ-jĕn). Digested starch stored in the body.
gossamer (gŏs′sȧ-mẽr). Any very thin gauzelike fabric; a fine, filmy substance like cobwebs.
granule (grăn′ūl). A little grain; a small particle; a pellet.
gullet (gŭl′lĕt). The tube by which food is carried from the pharynx to the stomach; the esophagus.

H

hair follicle (hâr fŏl′lĭ-k'l). A small cavity, or depression, at the outer end of a tiny tube, from which a hair grows.
hammer (hăm′mẽr). One of the three small bones in the ear. It gets its name from its likeness to a hammer.
hemoglobin (hĕm′ō-glōbĭn or hē′mṓ-glō′bĭn). The coloring matter of the red blood corpuscles.
hydrochloric acid (hī′drṓ-klō′rĭk ăs′ĭd). An acid contained in the gastric juice.

I

incisors (ĭn-sī′zẽrz). The teeth in front of the canines, or cuspids. They are used especially for cutting food.
inorganic (ĭn′ôr-găn′ĭk). Without the organs necessary for life; lifeless.
insoluble (ĭn-sŏl′ū-b'l). Incapable of being dissolved as by a liquid, as chalk is insoluble in water.
intestines (ĭn-tĕs′tĭnz). All of the alimentary canal from the stomach on down.
iris (ī′rĭs). The movable, muscular curtain lined with dark pigment found in the eye.

J

jaundice (jän′dĭs). A disease in which the eyes and skin turn yellow for one thing.

L

lachrymal gland (lăk'rĭ-mal glănd). The gland in which tears are formed.
lacteals (lăk'tē-alz). The small vessels which carry a milky fluid containing fatty matter from the small intestine.
larynx (lăr'ĭnks). The entrance to the windpipe.
ligaments (lĭg'ȧ-ments). Bands of strong connective tissue which unite bones and form joints.
liver (lĭv'ẽr). The organ, lying near the stomach, which manufactures bile.
lubricated (lū'brĭ-kā-ted). To make smooth or slippery (in order to cause to work without grating or friction).
lymph (lĭmf). The part of the blood that leaks from the blood vessels. It contains no red blood corpuscles.

M

maltose (malt'ōs). A crystalline sugar called malt sugar or maltose, derived from grains.
mastication (măs'tĭ-kā'shŭn). Chewing; as mastication of food.
medulla (mē-dŭl'lȧ). An expansion of the upper end of the spinal cord, which controls such reflex acts as breathing and the beating of the heart.
microbes (mī'krōbes or mĭk'rōbes). An organism so small that it cannot be seen by the naked eye.
microscope (mī'krō-skōp or mĭk'rō-skōp). An instrument by which the eye is enabled to see organisms too small to be seen without aid.
molars (mō'lẽrz). Any of the teeth back of the incisors and canines, used for grinding food.
mucous membrane (mū'kŭs mĕm'brān). The thin layer of tissue lining the passages and cavities of the body.

N

neuron (nū'rŏn). A nerve cell with its branches.
nitrogenous foods (nī-trŏj'ē-nŭs fo͞odz). Foods which contain the substance known as nitrogen.
nucleus (nū'klē-ŭs). The center of a cell.
nutrient (nū'trĭ-ent). Any food which nourishes.

O

olfactory nerves (ŏl-făk'tō-rў nẽrvz). The nerves in the nose upon which smell depends.
optic nerve (ŏp'tĭk nẽrv). The nerve from the eye to the brain upon which sight depends.

organic (ôr-găn′ĭk). A thing having organs; alive.
osseous tissue (ŏs′sė-ŭs tĭsh′ū). Tissue like bone; hard tissue.
oxygen (ŏks′ĭ-jĕn). A substance necessary to life, which the body takes in from the air.

P

palate (păl′āt). The hanging partition which separates the mouth from the pharynx.
pancreas (păn′krė-as). An organ near the stomach, in which a juice called pancreatic juice is formed to aid in digestion.
papillæ (pȧ-pĭl′lē). Tiny moundlike projections of the skin.
pepsin (pĕp′sĭn). One of the fluids composing the gastric juice.
peptone (pĕp′tōn). Fluid which is found in the gastric juice.
periosteum (pĕr′ĭ-ŏs′tė-ŭm). The membrane of fibrous connective tissue that covers all bones except at the joints.
peristaltic movements (pĕr′ĭ-stăl′tĭk mōōv′ments). Peculiar wormlike wave motion of the intestines causing the food to move on.
phagocytes (făg′ŏ-sītes). White blood cells that act as germ destroyers in the body.
pharynx (făr′ĭnks). The part of the alimentary canal between the mouth and the esophagus.
plasma (plăz′mȧ). The fluid part of the blood in which the cells float.
posterior chamber (pŏs-tē′rĭ-ẽr chām′bẽr). The enclosed space in the eye behind the lens.
protein (prō′tė-ĭn). One of the class of nutrients which furnishes building material for the body.
protozoa (prō′tŏ-zō′ȧ). Tiny animals that grow in the body and cause disease.
pupil (pū′pĭl). The opening of the eye, in the center of the iris.
pus (pŭs). A collection of dead white cells.
putrefy (pū′trė-fī). To decay; to rot.
pylorus (pī-lō′rŭs). The opening of the stomach into the intestine.

R

rennin (rĕn′nĭn). One of the fluids composing the gastric juice.
respiration (rĕs′pĭ-rā′shŭn). The act of breathing.
retina (rĕt′ĭ-nȧ). The inner coat of the eyeball containing the nerve cells and fibers necessary for sight.

S

saliva (sȧ-lī′vȧ). The fluid found in the mouth and manufactured in the salivary glands; necessary for the digestion of starch.
salivary glands (săl′ĭ-vȧ-rȳ glăndz). Tiny sacs in the lining of the mouth that produce the fluid called saliva.

scavenger (skăv'ĕn-jẽr). One who cleans, removes waste, makes things healthy by removing dirt and germs that breed disease.

sclerotic (sklė-rŏt'ĭk). The outer coat of the eye.

sebaceous (sė-bā'shŭs). Composed of fat; containing fat.

sedentary (sĕd'ĕn-tā-rȳ). Inactive physically; requiring much sitting.

septum (sĕp'tŭm). A partition separating the nostrils or nasal cavity into two parts.

serum (sē'rŭm). The pale yellowish fluid that comes out from a clot of blood.

spasmodic (spăz-mŏd'ĭk). Convulsive, irregular, jerky, uneven.

spirometer (spī-rŏm'ė-tẽr). An instrument for measuring the capacity of the lungs.

stagnant (stăg'nant). Not flowing; motionless, as stagnant water in a ditch.

stimulus (stĭm'ū-lŭs). Something that rouses to action, as stimulus to sight or hearing or taste.

stirrup (stẽr'rŭp). One of the three small bones of the ear. It gets its name from its shape.

stomach (stŭm'ak). The cavity in the body made by the enlargement of the alimentary canal, which lies above the intestines.

suspensory ligament (sŭs-pĕn'sō-rȳ lĭg'ȧ-ment). A suspended or hanging band of connective tissue.

symmetrical (sĭm-mĕt'rĭ-kal). Having one side like another; even, regular.

T

thoracic duct (thō-răs'ĭk dŭkt). The great trunk of the lymphatic vessels, between the intestines and the heart.

thorax (thō'răks). The part of the trunk between the neck and the abdomen.

tissue (tĭsh'ū). The fibers that go to make up organs of any sort, as the heart or lungs.

tonsil (tŏn'sĭl). One of the two organs placed on each side of the throat, and serving to destroy germs on the way to the lungs.

trachea (trā'kė-ȧ or trȧ-kē'a). The windpipe.

tympanic membrane (tĭm-păn'ĭk mĕm'brān). The delicate skin in the ear stretched across the lower end of the canal. It is called the drum.

V

ventricle (vĕn'trĭ-k'l). One of the cavities of the heart, which forces the blood from the heart into the arteries.

vertebræ (vẽr'tė-brē). (Plural of vertebra.) The bones of the spinal column.

villi (vĭl'lī). (Plural of villus, which is rarely used.) The tiny, fine, finger-like projections which cover the lining of the stomach.

INDEX

THE following pages contain advertisements of a few of the Macmillan books on kindred subjects

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In this volume are found interesting chapters on New England and its manufacturing, Western plains and agriculture, the Southern states and cotton, Mexico and its troubles, Central America and its problems, Alaska and its resources, Canada and her people, the Panama Canal and its opportunity, and numerous other chapters.

Europe

The treatment of Europe is particularly interesting because of the extended description of Germany and her industries, France and her people, the British Isles and its history, Russia and her problems, the Balkan countries and their independence.

South America

The treatment of South America covers the industrial side of geography. These topics are typical: The Coffee Industry in Brazil, The Cocoa Industry in Ecuador, Agriculture in Argentine, The Tea Industry in Paraguay.

Asia

In the volume on Asia we have interesting chapters on Japan, the Chinese republic and the progress that is being made by the Chinese, India and her government under the British Empire, the Holy Land and its place in history.

Africa

The treatment of Africa tells of the progress that is being made by European nations in the colonizations of the continent. It relates the history of ancient Egypt, the development of commerce along the trade routes and tells stories of the great industries that have been established within recent years.